Flammability Testing

(NASA-STD-6001: Tests 1, 8, 10)

! This Instruction Contains Descriptions of **HAZARDOUS OPERATIONS** !

Materials and Processes Laboratory
Materials Test Branch, Building 4623

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Release Authority	Name	Title	Organization	Date
Office of Primary Responsibility	[s] Gail H. Gordon	Materials Test Branch Chief	EM10	11/15/05
	[s] Dennis Davis	Industrial Safety	QD50	11/16/05

Revision	Date	Originator	Description	Affected Pages
Baseline	2/4/05	Eddie Davis	Document converted from ED36-OWI-034. Previous history retained in system as part of canceled or superseded ISO Document files.	All
A	11/17/05	Eddie Davis	Hazardous Operations notification added to cover	Cover, ii

This document baselines the Organizational Work Instruction (OWI) for conducting standard and configuration flammability testing in the small and large flammability test systems in Building 4623. Any deviation to this OWI shall be approved by the test engineer via an approved test plan. Any changes to the test equipment shall be noted on the tester maintenance log and approved by the test engineer. It is the responsibility of the test engineer to obtain NASA Contracting Officer's Technical Representative (COTR) approval where necessary for changes to the test equipment.

Any change to this OWI shall be submitted to and approved by the Materials Test Branch Chief, EM10. Revisions may be also be submitted to the concurring organizations listed below for review and concurrence by memo. The original OWI and all changes shall be maintained by EM10. Any change to materials used shall first have EM10 Chemistry Team Lead approval and shall include a change to mechanical drawings. All documentation shall be approved by the appropriate persons mentioned above and incorporated into the OWI before operation of the reconfigured test equipment resumes.

Concurring organizations:
Building 4623 Test Operations Contractor
EM10 Chemistry Team Lead
Environmental Health, AD60M

Contents

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1.0 Scope

1.1 Scope

The scope of this Organizational Work Instructions (OWI) is NASA-STD-6001, Tests 1, 8, and 10, Standard and Configuration Flammability Testing, as performed in Building 4623 at Marshall Space Flight Center.

1.2 Purpose

The purpose of Tests 1, 8, and 10 is to analyze potential aerospace flight materials and small components for various ignition and burning characteristics. Specifically, the tests determine the ability of materials to resist ignition or to self-extinguish once ignited without transferring burning debris to adjacent materials.

1.3 Applicability

This instruction applies to the Chemistry Team, Materials Test Branch, of the Materials and Processes Laboratory.

2.0 Applicable Documents

EM10-OWI-CHM-042. *Test Sample Preparation for Testing in Building 4623.*

EM10-OWI-CHM-050. *Building 4623 Guidelines for Test Operations.*

EM10-OWI-CHM-051. *Receipt, Handling, Prioritizing, and Data Requirements of Samples Submitted for Testing in Building 4623 of the Materials and Processes Laboratory*.

EM10-OWI-CHM-058. *Chemical Hygiene Plan for Building 4623*.

MPD 1840.3. *MSFC Respiratory Protection Program*.

MPR 1040.3. *MSFC Emergency Plan.*

MPR 1840.2. *MSFC Hazard Communication Program*.

MPR 8715.1. *MSFC Safety, Health, and Environmental (SHE) Program.*

MPR 8823.2. *Pressure Systems Guidelines and Certification Requirements.*

MWI 3410.1. *Personnel Certification Program.*

MWI 8621.1. *Close Call and Mishap Reporting and Investigation Program*.

NASA-STD-6001. *Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments That Support Combustion*.

Note: Personnel **shall** always **refer** to the current revision of each applicable document.

3.0 Definitions

3.1 Definitions

Burn length. The distance from the bottom of the sample to the farthest point over which the sample has been consumed (not including portions of the sample that have been damaged or discolored from the heat of the flame).

Burn propagation rate. The rate at which a sample burns, found by dividing the burn length by the propagation time.

Burn propagation time (upward burn time). The time that elapses from ignition of the sample until the flame propagation stops.

Flame jet. A flame or flames that flare beyond the main flame front.

K-10 paper. Paper used in flammability testing to determine transfer of burning debris. Shall meet Federal Specification UU-P-258.

NASA. Marshall Space Flight Center EM10 responsible personnel.

Oxygen-enriched environments. Oxygen level in air is greater than 23.5%. When referenced during chamber evacuation procedures in this OWI, the term *oxygen enriched* means any oxygen level over 20.9%.

Pre-mixed gas. Compressed gas used in flammability testing and delivered in the pre-mixed concentration of approximately 30.5% oxygen and 69.5% nitrogen. Currently, no other pre-mixed concentrations are used for flammability testing.

Self extinguish. A material is considered to self extinguish if it has a burn length of less than 6 in. (15 cm) when exposed to an ignition source.

Smolder. To burn or smoke without visible flame.

Spark. To emit fiery particles.

Standard sample. For Test 1, a solid material 0.010 in. (0.025 cm) thick or more and 12 in. long by 2.5 in. wide or a coating material applied to a 12- by 2.5-in. aluminum substrate.

Tag out. The placement of a tag-out device on an energy-isolating device to indicate that the energy-isolating device and equipment being controlled shall not be operated until the tag-out device is removed by the person who placed it there.

Test 1. Upward flame propagation testing according to NASA-STD-6001.

Test 8. Flammability testing for materials in vented or sealed containers according to NASA-STD-6001.

Test 10. Flammability testing of a simulated panel or major assembly according to NASA-STD-6001.

Test area. The portion of Building 4623, including the fenced area, south of the north wall of Room 126.

Test cell. The separate areas within Room 126 (126B and 126C) that house the large and the small flammability test chambers.

Test engineer. The person responsible for correctly following the approved test plan for a specific test from sample receipt to test data evaluation.

Test operator. The person responsible for conducting the test under the guidance of the test engineer.

Thin film samples. Samples, excluding fabrics or coatings applied to a substrate, with a total thickness of less than 0.010 in. (0.025 cm). These samples are 12.0 in. long by 3.0 in. wide.

Total burn time. The total time elapsed from ignition of the igniter to the last evidence of flame, glow, or smoldering.

Transfer of burning debris (drip burn). The potential spreading of flames by movement of burning particles from a burning sample to adjacent materials.

3.2 Acronyms

ECV Electronically controlled valve

GN_2 Gaseous nitrogen

GOX Gaseous oxygen

MSDS Material Safety Data Sheet

MSFC Marshall Space Flight Center

NIST National Institute of Standards and Technology

OWI Organizational Work Instruction

4.0 Instructions

All operations of this equipment shall be conducted using the applicable documents referenced above (section 2). All critical measuring devices, *e.g.*, pressure gauges, oxygen analyzers, power supplies, shall be in current calibration (section 9.5). All data and test results shall be recorded on form EM10-F-CHM-010, the Test 1 Flammability Test Data Sheet (section 7.2, Figure 10). All testing shall be videotaped. A summary of pertinent test information and test results shall be compiled in a NASA memo, signed by the test organization management, and mailed to the test requester.

4.1 Sample Preparation

Personnel **shall refer** to EM10-OWI-CHM-042, *Test Sample Preparation for Testing in Building 4623*, for information on standard flammability sample preparation. When configuration, component, assembly, or non-standard samples are received for testing, the test plan for that test request shall contain the specific method(s) of sample preparation required for that test request. *If this information is not provided with the test plan,* personnel **shall not continue and shall seek** clarification of preparation requirements from the test engineer.

The *test operator* shall:

- **Review** the information supplied on the test data sheet (prepared by the sample preparation technician) to make certain the information appears sound.
- **Take special care** to note the test number and material designation, verifying that it is identical on all paperwork.
- **Confirm** that the prepared samples agree with the test request.
- **Note** any flaws or imperfections in the sample, and **record** these on the flammability data sheet.
- **Review** the test plan signed by NASA and the original test request before proceeding. *If the test plan and the test request do not agree*, **seek clarification from the test engineer**.

4.2 Pre-Test Photography

The *sample preparation technician* **shall take** a pre-test photograph of one of the samples and **place** three copies in the test folder. In addition, any irregular test samples shall be photographed for documentation. The *test operator* **shall verify** that this photo has been taken before proceeding with the test, and *if the photo has not been taken,* **shall take** the photo, ensuring that the entire length of the sample is visible in the photo and that the photo is properly focused, illuminated, and exposed. The *test operator* shall **include** a measuring scale in the photo for reference. Steps for photographing samples are outlined in the *Photography Operating Guide*.

4.3 Equipment Checkout

4.3.1. The *test operator* shall **inspect** *t*he test equipment daily, according to the following steps, before beginning testing, and **shall refer** to Figures 1 through 7 as needed.

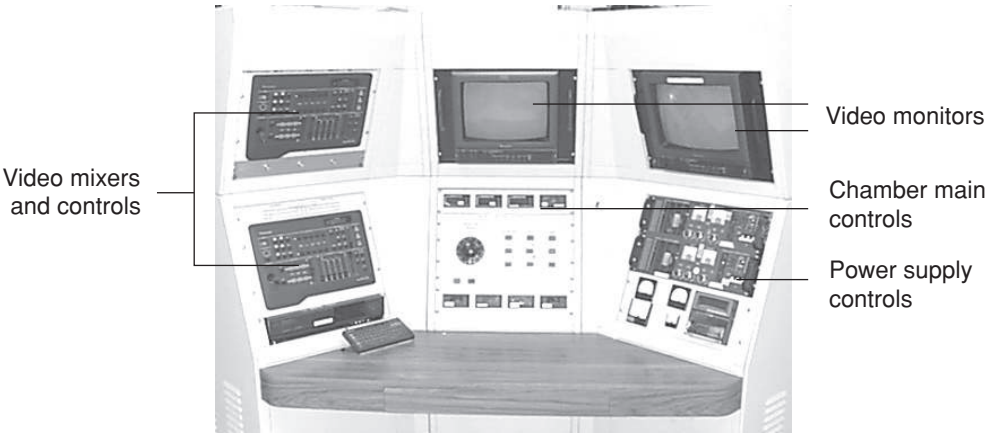


Figure 1.
Master Console for Small Flammability Chamber. Console for Large Flammability Chamber is arranged in mirror image but is otherwise identical.

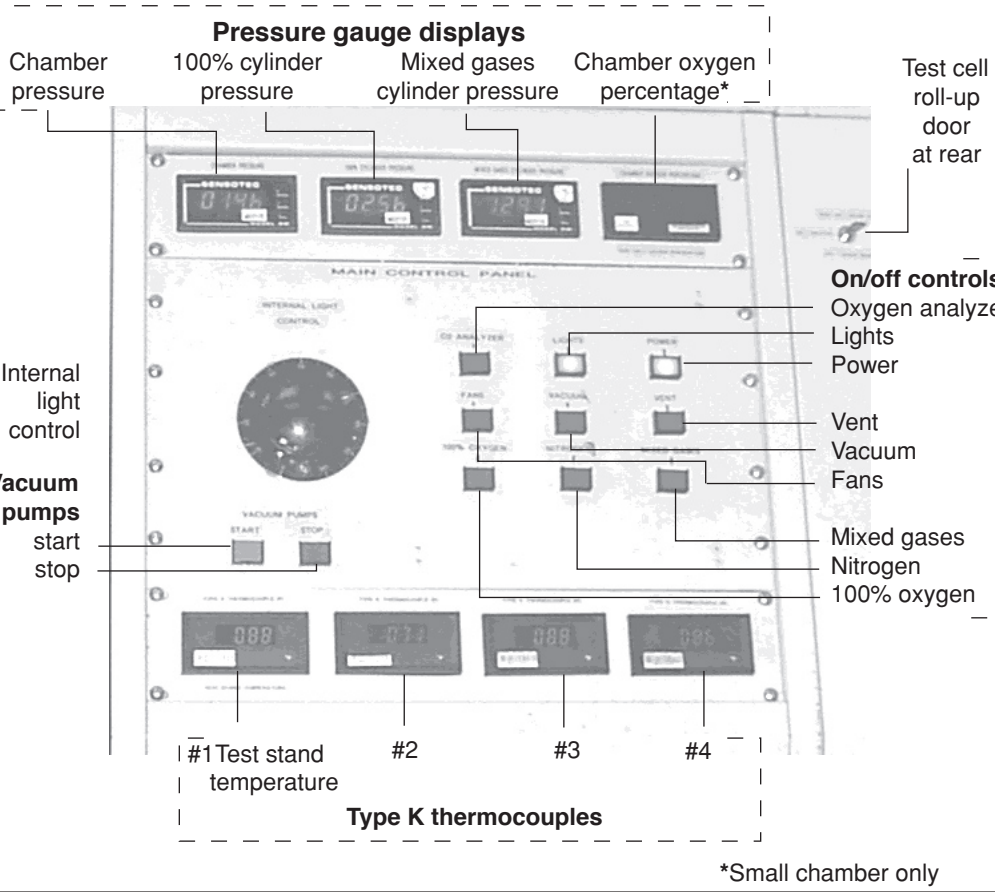


Figure 2.
Main Control Panel for Flammability Chambers. Note that one pressure gauge display (shown here on the small chamber control panel) is not on the large chamber. This difference does not affect operations.

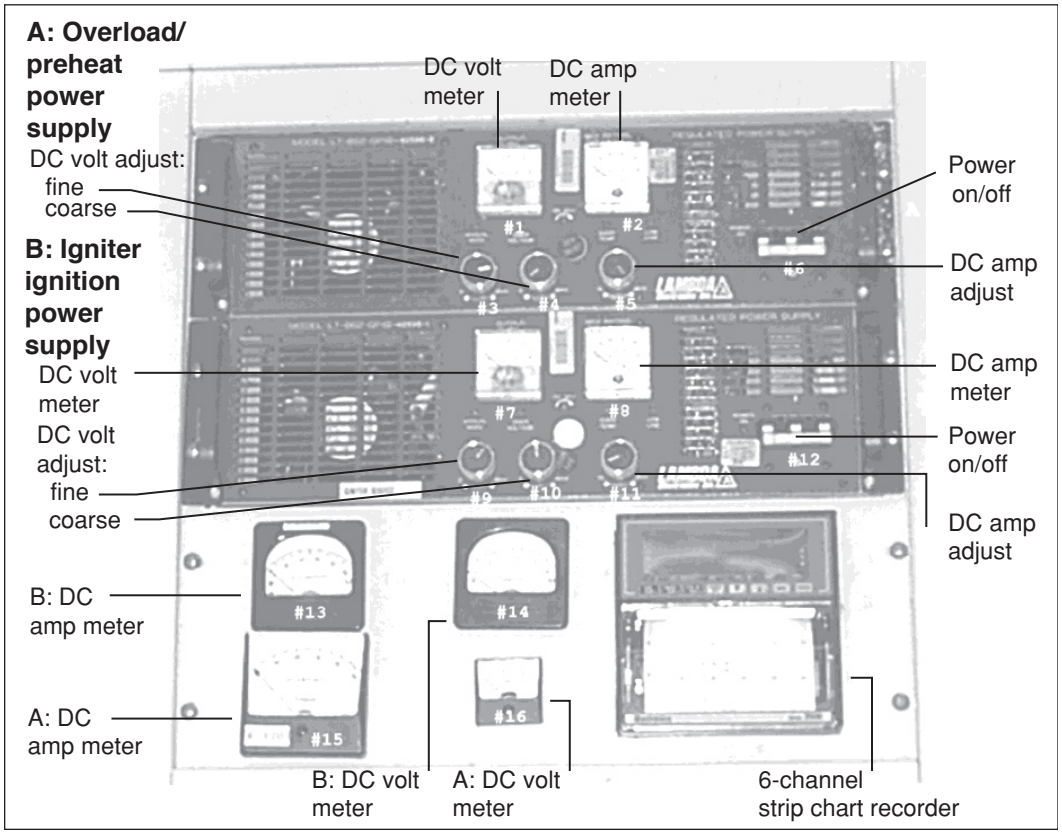


Figure 3.
Primary Power Supplies for both the Large and Small Flammability Chambers.

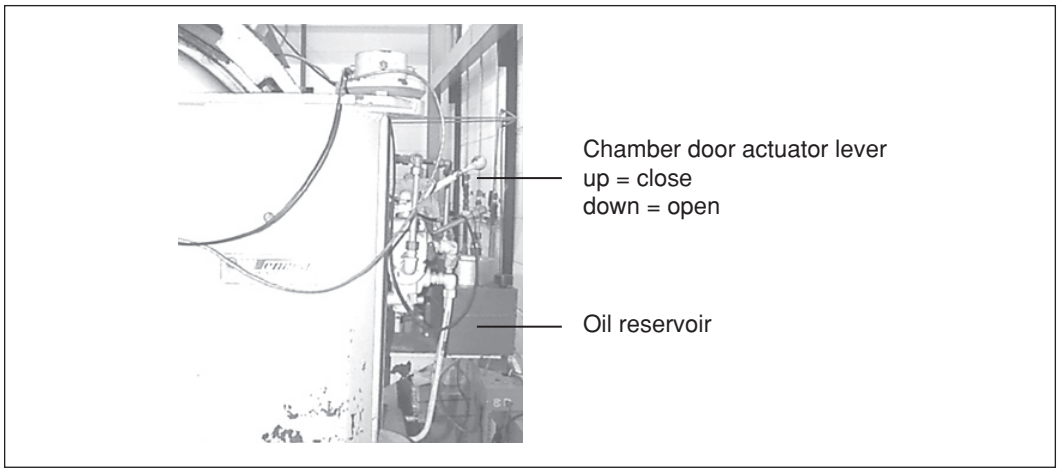


Figure 4.
Chamber Door Actuation System (Small Flammability Chamber).

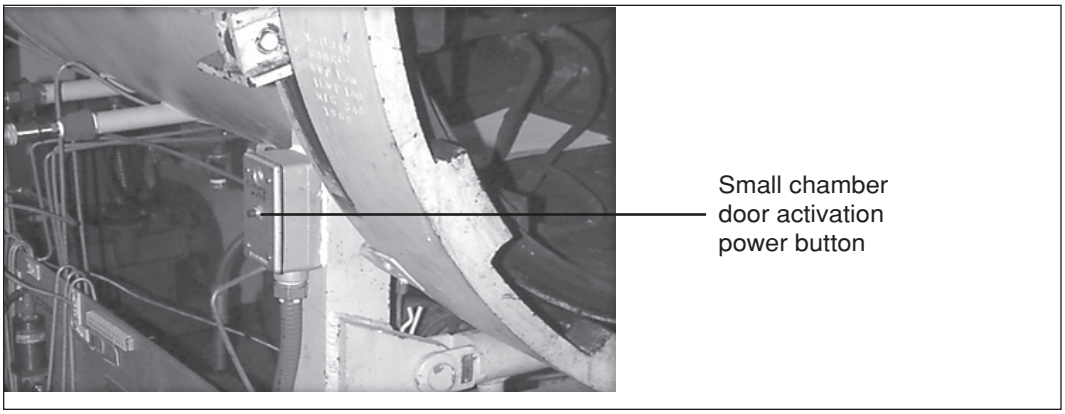


Figure 5.
Power Switch for the Small Flammability Chamber Door (located on the chamber stand).

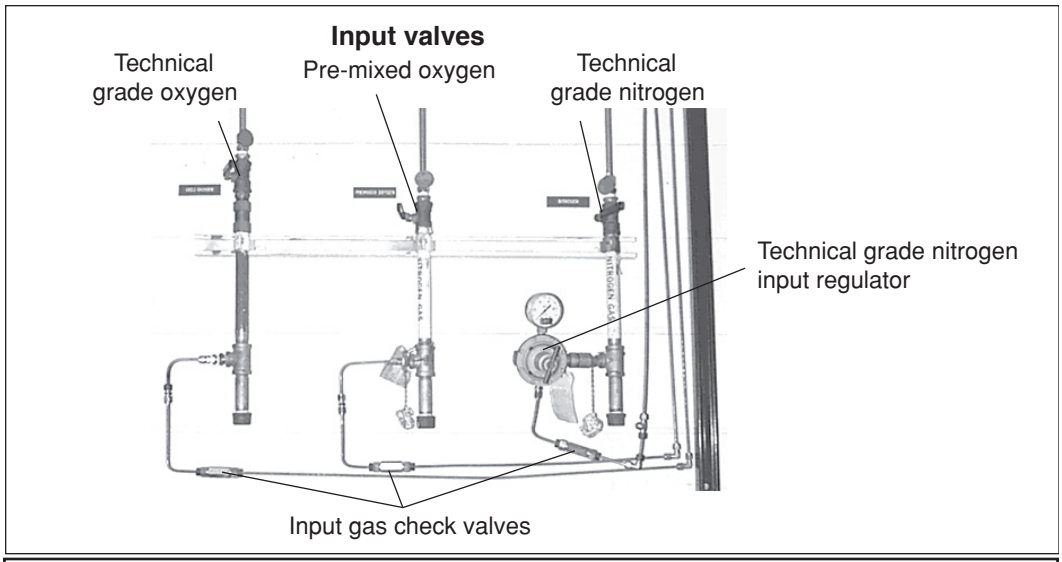


Figure 6.
Input Gas Manual Controls for the Large and Small Chambers.

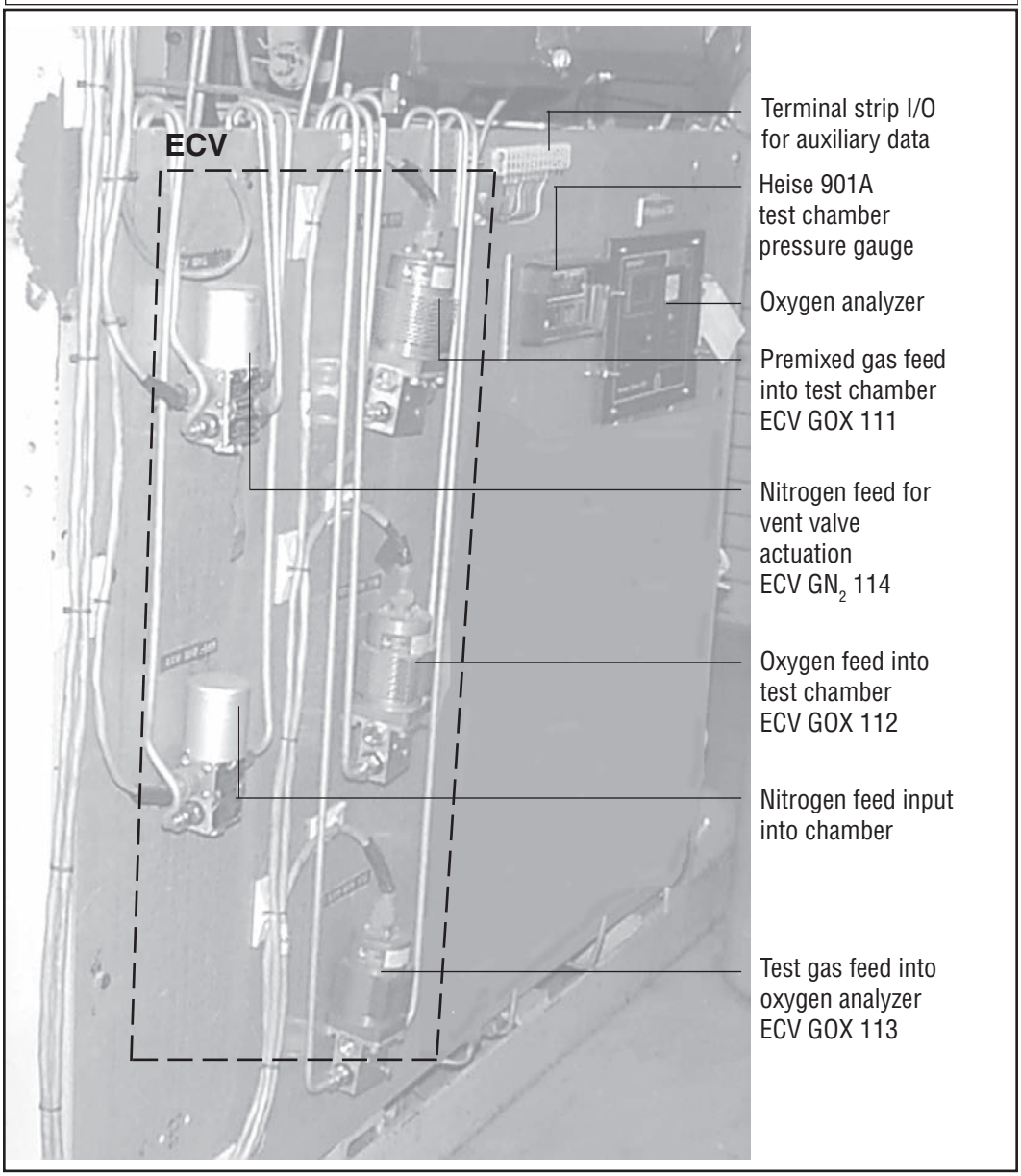


Figure 7.
Small Test Chamber Equipment Panel.

4.3.2. **Observe** the oxygen monitors (Zone 13 for the large flammability chamber and Zone 14 for the small flammability chamber) located on the east wall of the break room. The oxygen level indicated by the digital readout shall be between 19.5% and 23.5% oxygen.

4.3.3. **Ensure** the Servomex Oxygen Analyzer is on; **turn on** the analyzer pump and analyzer ECV. *If the analyzer is not reading 20.8 to 21.0*, **check** the calibration (span only) with a certified gas (a pre-mixed compressed gas bottle of known concentration with certification traceable to NIST). (Section 9.3 contains maintenance and calibration procedures for this unit.) The analyzer pump and solenoid valve are the only items that are to be powered on and off each day. **Check** the analyzer weekly with a known gas, and **record** that information in the log book for the tester.

Note: I*f the power to the analyzer is off,* a warm-up time of 4 hours is required.

4.3.4. **Turn on** power to:

- **Video equipment** (monitors, VCRs, cameras, etc.) (Figure 1)
- **Main Control Panel** (After power is applied, all electronic control valves, the vacuum pump(s), and the fan(s) remain off.) (Figures 1 and 2).

4.3.5. **Verify** that the thermocouple readouts and the chamber pressure transducer readouts on the Main Control Panel are working properly (Figures 1 and 2). The thermocouple readouts shall be reading ambient temperature, and the chamber pressure transducer readout shall read 14.5 psia ($\pm$0.5 psia, depending on atmospheric conditions), when the chamber door is open. *If not,* **notify** the test engineer of the problem

4.3.6. **Check** the calibration dates on all calibrated equipment. **Replace** any equipment that is out of calibration and prepare the equipment to be sent to the calibration laboratory. **Record** the replacement of out-of-calibration equipment in the maintenance log.

4.3.7. **Inspect** wiring for any visible signs of wear or damage. *If using a standard chemical igniter,* **check** the operation of the ignition system by clamping a 20-gauge nichrome igniter wire on a test stand and applying 8 volts, 14 amps (nominal) to the circuit. *If using a silicon igniter,* **clamp** an 18-gauge nichrome wire to the test stand, and **apply** 11 volts and 20 amps (nominal) to the circuit. **View** the wire test on the monitor from the test console, since no personnel are allowed in the test area when power is on to the ignition system. The wire shall begin to glow in 3 to 5 seconds after initiation of power to the circuit. *If the wire does not glow after 5 seconds,* **notify** the test engineer of the problem.

4.3.8. **Inspect** the door gasket for signs of wear or deterioration such as rips or tears. **Replace** the gasket *if there are major signs of deterioration,* using only a thin film of perfluoroether grease (Krytox® 240AC) for lubrication.

4.3.9. **Perform** a leak check. **Evacuate** the test chamber to the lowest attainable pressure (0.2 to 0.5 psia), and **hold** for 1 minute. No more than a 0.2 psia per 2 minute leak rate is allowed. (This step may be combined with the testing of the first sample of the day to save time). *If the chamber leak rate exceeds the allowed amount and a cursory examination of ports and seals does not identify the problem*, **notify** the test engineer.

4.4 System Setup and Sample Loading

The test operator **shall perform** the following procedures:

CAUTION: **Verify** igniter and preheat power supplies are off before working in the chamber.

4.4.1. **Ensure** that the test chamber is clean (vacuum, wash view ports, clean sample holders, etc.).

4.4.2. **Ensure** that all required safety equipment is available and in proper working order. Safety equipment needed includes clean laboratory jacket, respirator, safety glasses, gloves, and safety shoes.

4.4.3. **Determine** if special testing procedures (section 4.6) are applicable. **Inspect** the contents of the current test folder to ensure that all the necessary information is provided:

- Test request
- Signed test plan
- Test data sheets, with weights/measurements filled in by sample preparation laboratory personnel
- Sample preparation sheet
- Test material's MSDS or the Exclusion Statement for the material/component being tested
- Pre-test photographs
- Flammability Test Chamber Pre-Test Checklist.

Note: Read the test material's MSDS to ensure familiarity with all safety precautions associated with the material. Verify that the test engineer is aware of all highly hazardous, reactive, or toxic components of the test material. The *test engineer* **shall direct** the test operator in proper safety procedures concerning these test materials.

4.4.4. **Obtain** the latest available video cassette numerically identified by the year (96-, 97-, etc.) followed by the tape number (-01, -04, etc.). If the time remaining on the cassette is less than 25 minutes, start a new tape and identify the tape with the next available tape number in the video tape log book in the video file cabinet. The video tape in use is left in the recorder on the flammability console.

4.4.5. **Record** the video cassette number and the test start counter/frame number on the test data sheet.

4.4.6. **Prepare** a test information sign for the video tape by using the character generator. **Refer** to section 7.1.1 for information on operation of the character generator. **Record** the test information sign on video for at least 10 seconds. **Stop recording** after this time. The test information sign shall contain the following information:

- Request number
- NASA-STD-6001 Test 1 (8 or 10)
- Sample number
- Test atmosphere
- Test pressure
- Material designation.

4.4.7. **Ensure** the video system is operating properly by checking chamber views. This is accomplished by switching the view buttons at the top of the panel to the left of the Main Control Panel.

CAUTION: **Verify** igniter and preheat power supplies are off before working in the chamber.

4.4.8. **Mount** samples in the appropriate test stand following instructions for the test type.

(a) Test 1 Upward Propagation Standard Samples. A standard sample (2.5 x 12.0 in. x use thickness) shall be mounted in a standard test stand (Figure 12, section 9.1). The standard test stands are made from aluminum or stainless steel. **Use** the aluminum test stands for testing in ambient environments only, as aluminum burns readily in enriched oxygen atmospheres. The sample shall be mounted so that the burn area is approximately 2 in. wide and clamped securely enough to inhibit the sample from sagging or falling out of the test stand during burning. The sample shall not be clamped with a force so great that the sample is in any way stressed or deformed (swelling, cracking, etc.). The sample shall be clamped along the entire length of the sample. Thin film samples (cut to 3.0 x 12 in.) shall be clamped in a standard test stand so that 2.5 in. of the sample are exposed to the ignition source; this produces horizontal slack. As an option, thin films may be mounted using the needle rake test stand (section 9.1, Figure 13).

Remember AA: Aluminum=Ambient O_2 level

(b) Test 1 Upward Propagation Non-Standard Samples. Samples such as heat shrink tubing, lacing tape, and any material that does not clamp into the standard test stand shall be mounted vertically (unless the test plan states otherwise) using the needle rake test stand. If the needle rake test stand is unsuitable for the given configuration, alligator clips and wire shall be used. **Place** the clips so that they present the minimum heat sink possible. Wires tested in Test 1 shall be tested in a "J" configuration, with the short leg of the "J" being 3 inches long and the long leg approximately 9 inches long. **Fully detail** the holder configuration in the remarks section of the test data sheet. Also, whenever a sample mounting configuration does not use either the standard test stand or the needle rake test stand, the test engineer shall document and approve the mounting technique. For samples mounted using non-standard techniques, **photograph** the sample/test stand configuration to display clearly the ignition source relative to the sample. **Mount** samples that are of a non-standard length, but standard width, as described in the previous paragraph.

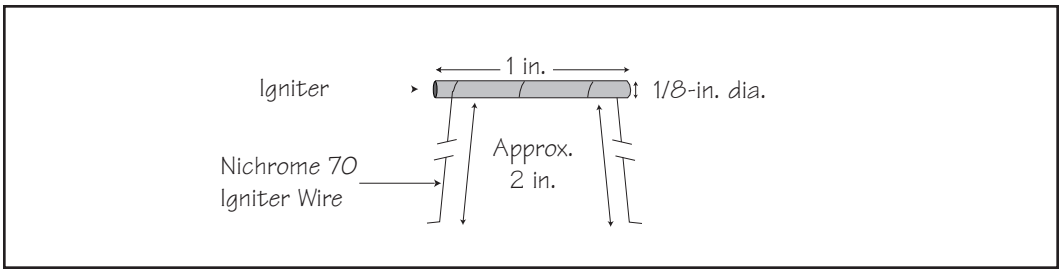
(c) Test 8 and Test 10 Configuration Samples. **Mount** the sample according to the instructions provided on the test plan. *The test engineer* shall document and approve the mounting technique. The mounting method and the sample shall be **detailed explicitly** on the test data sheet in the remarks section.

4.4.9. **Place** mounted sample into the test chamber:

(a) Test 1 Upward Propagation, including Standard and Non-Standard Sample Sizes: **Place** test stand in the test chamber, ensuring that the stand is vertically and horizontally level and that the bottom of the sample is approximately 10 in. from the floor of the chamber. **Position** a thermocouple on the test stand to monitor the test stand temperature. The test stand temperature shall be below 100 ˚F to prevent pre-heating of the sample. *If the test stand temperature is above 100 ˚F,* **replace** the hot test stand with one that is at ambient temperature.

(b) Test 8 and Test 10 Configurations, Angled or Horizontal Propagation: **Set** the test stand in the chamber so that the stand is vertically and horizontally level. **Position** a thermocouple on the test stand to monitor the test stand temperature. The test stand temperature shall be below 100 ˚F to prevent pre-heating of the sample. *If the test stand temperature is above 100 ˚F,* **replace** the hot test stand with one that is at ambient temperature.

4.4.10. **Prepare** the ignition source unit. **Use** the standard chemical igniter for testing up to 40% oxygen. *Above 40% oxygen*, **use** the silicon igniters. **Use** a clean nichrome 70 igniter wire (20 gauge for chemical and 18 gauge for silicon) and a dry igniter. The igniter wire shall be cut to a length that is appropriate for the thickness of the test sample. The length of the igniter wire shall include a coil that shall wrap around the igniter no less than three times (Figure 8) with approximately equal lengths of wire left at each end for clamping into the power supply circuit. If, when mounted in the test fixture, the length of the igniter wire



Note: Illustration is representative. Actual appearance may vary.

Figure 8.
Typical Igniter with Three Equally Spaced Wraps of Nichrome 70 Igniter Wire.

needs shortening bending the wire or trimming the ends is allowed. When bending the igniter wire the wire shall be not allowed to touch itself. **Refer** to section 7.1.2 for igniter storage, standards, care, and verification.

4.4.11. **Place** the ignition source unit on the test stand.

(a) Test 1 Upward Propagation, including Standard and Non-Standard Samples: **Place** the igniter 0.25 (± 0.01) in. below the bottom of and parallel to the front leading edge of the sample, centered to the width of the sample. This is **standard igniter placement**. Deviations from standard shall be noted in the test plan and require approval from the test engineer. **Note** the deviations in the test data sheet Remarks section.

(b) Test 8 and Test 10 Configurations, Angled or Horizontal Propagation: **Place or create,** as dictated by the test plan, an ignition source unit on the test stand. **Detail** explicitly the placement of this item in the remarks section of the test data sheet. **Photograph** the sample/test stand configuration to display clearly the ignition source relative to the sample.

4.4.12. **Place** a sheet of K-10 paper (8.5 x 11.0 in.) into the slot of the standard test stand (or approximately 8.0 in. below the sample and above the chamber floor for configuration or special tests not using the standard test stands). The K-10 paper is not required for Test 8 or Test 10, unless specified in the test plan. *If the K-10 paper ignites during testing and appears to affect the burning characteristics of the material (re-ignition of the sample, aggravated flame spread, etc.)*, **note** the effect in the Remarks section of the test data sheet.

4.4.13. **Verify** the camera view(s) of the sample in the chamber. **Ensure** that the sample is clearly and completely displayed in the camera view(s). **Ensure** adequate lighting of the sample. The lighting control is located on the Main Control Panel (Figure 2). It is usually set at 60% of maximum. Adjustment of this control is allowed but **be sure not to pre-heat** the sample with the lights. (**Watch** the thermocouple readouts.) **Ensure** that one of the camera views includes the K-10 paper, if used during test.

4.4.14. **Close** the chamber door. *For the small chamber,* **close** the door by setting the chamber door actuator lever to the close position (up) (Figure 4) and applying

power to the hydraulic pump until the rotating door clamp stops. The power button for activating the small chamber door clamp is located on the chamber stand directly to the left of the door (Figure 5). *For the large chamber*, **close** the door by initiating power to the drive motor and maintaining power to the drive motor until the door clamps have reached a position where the safety latch engages. The power switch for the large chamber door drive motor is located on the wall to the right of the chamber. Moving the switch down closes the door clamps.

4.4.15. **Ensure** that the proper pre-mixed gas or other gas sources are on-line and that there is sufficient pressure in the gas source to pressurize the test chamber to the desired pressure. *If the gas source is the N_2 and O_2 reducing panels,* **ensure** that the High Pressure Gas Bottle isolation valves are CLOSED, that the N_2 and O_2 reducing panel outlet isolation valves are OPEN, and that the regulated gas pressure is approximately 100 psig. *If the gas source is a group of High Pressure Gas Bottles connected via a gas manifold*, **ensure** that the N_2 and O_2 reducing panels outlet isolation valves are CLOSED and the High Pressure Gas Bottle isolation valves are OPEN. *If a valve is not open on a given bottle,* then **completely reduce** the downstream supply regulator, and **slowly open** the valve on the bottle. **Continue** in this manner until all bottles on the manifold are opened; then **slowly increase** the supply regulator until the output pressure reads approximately 100 psig.

4.4.16. **Fill out** the pre-test checklist (Figure 9, section 7.2).

4.5 Detailed Test Procedure

The test operator **shall perform** the following procedures:

4.5.1. **Verify** that the vent is closed by ensuring that the **VENT** ECV button is not lit. **Press** the **VACUUM** button, which opens the vacuum gate ECV. Simultaneously **press** the **VACUUM PUMPS START** button and the **STOP WATCH START STOP** button to evacuate the chamber down as far as possible in a 4-minute time span. At the end of 4 minutes, **press** the **VACUUM** button again to close the vacuum gate ECV. **Press** the **VACUUM PUMPS STOP** button to turn off the vacuum pumps. **Press** the **STOP WATCH START STOP** button to stop the stop watch.

Note: *If a vacuum of at least 0.3 psia is not achieved,* **check** (a) the chamber for leaks and (b) that the chamber pressure gauge is functioning properly

4.5.2. **Fill** the chamber to 14.7 psia. **Press** the **MIXED GASES** ECV button *if testing at 30% oxygen.* **Press** the **100% OXYGEN** ECV button *if testing at 100% oxygen*. **See** section 7.1.3 for instructions on post-fill mixing of gases to achieve a desired test environment, if it is other than that available in the pre-mixed bottles. *If using the post-filling method*, **identify** the test on the test data sheet

as non-standard. In the Remarks section, **note** that the post-fill mixing method was used to achieve the test oxygen concentration.

4.5.3. **Press** the appropriate ECV button again when 14.7 psia is reached. **Press** the **OXYGEN ANALYZER** button to analyze the oxygen level of the test chamber environment to ensure that the test chamber environment is within +1/-0.3% of the test procedure's specified oxygen concentration. This reading appears on the **OXYGEN ANALYZER** display and is monitored remotely by video camera. *If the appropriate test environment cannot be established through the post-fill method*, **check**:

- Filters for contamination/jamming
- Oxygen analyzer pump for damaged bellows or a cracked diaphragm
- All plumbing for leaks.

4.5.4. **Record** the oxygen concentration (switch to the appropriate view) on the video tape of the test just before initiation of the test.

Note: Verify the oxygen concentration, as described above, at a chamber pressure of 14.7 (±0.2) psia.

4.5.5. After the correct oxygen concentration for the requested test is verified, **turn** off the fans, and **evacuate** or **fill** the test chamber to the desired test pressure. To evacuate, **open** the vacuum gate valve, and then **press** the **VACUUM PUMPS START** button. The vacuum pumps shall run until the test chamber pressure is 0.3 to 0.4 psia below the desired test pressure. **Press** the **VACUUM** button to **close** the vacuum gate valve.Two seconds after the **VACUUM** button is pressed, **press** the **VACUUM PUMPS STOP** button. This method compensates for the pressure rebound effect caused by the sudden removal of the vacuum force on the gas molecules and allows the chamber pressure to settle within the test's pressure tolerance of ±1%. For chamber test pressures equal to or higher than 14.7 psia, **fill** the chamber with the calculated test atmosphere until the test pressure is reached.

4.5.6. **Soak** the test sample in the test environment at the desired oxygen concentration and test pressure for 3 minutes or as directed in the test plan. Use the stop watch function on the character generator to time the 3-minute hold, and as the hold time approaches the end, **record** the last 10 seconds (approximately) to verify the hold time. **Stop** and **reset** the timer.

4.5.7. *If using the post-fill method of mixing gases,* **ensure** that the test chamber fan is **off,** *i.e.*, the **FANS** control button is not lit, and that the video system is showing the appropriate test chamber view(s).

4.5.8. For all tests, **verify** that the VCR is still recording. **Note** the initial temperature in the test chamber by checking the thermocouple meters on the Main Control Panel. **Record** this information on the test data sheet. For Tests 1 and 2, **initiate** power to the igniter, and **start** the timer (located on the character generator control board) immediately upon ignition of the igniter. Then **turn** the power to the igniter **off**. For Test 8 or Test 10, **follow** instructions on the test plan for ignition, and **start the timer** immediately upon ignition of the igniter.

4.5.9. While the test is in progress, **observe** the sample and igniter closely. **Note** that the standard chemical igniter used for 40% or less oxygen is to burn 25 ±5 seconds. *If the chemical igniter does not burn 25 ±5 seconds,* **consult** the test engineer for directions concerning the testing of an additional sample. Silicon igniters, which are used above 40% oxygen, always burn longer than 25 (±5) seconds. This is accepted practice. When the sample extinguishes, **allow** the timer to continue to run for another 20 to 30 seconds while observing the sample for a recurring flame or glow. **Stop** the timer and video recording *if no flame or glow is visible.* **Record** the post-test chamber temperature on the test data sheet.

4.5.10. **Determine** the remaining oxygen concentration using the following procedure:

4.5.10.1. *When the test environment pressure is below 14.7 psia,*

- **Record** the post-test chamber pressure (PTCP).
- **Backfill** the chamber with GN_2 by pressing the **NITROGEN** ECV control button. **Turn on** the chamber fans by pressing the FANS button. (**Fill** until the chamber pressure is between 14.8 and 15 psia.) **Stop filling** by pressing the **NITROGEN** ECV button again.
- **Press** the **OXYGEN ANALYZER** ECV control button.
- **Record** the analyzer value (BFAV) and the exact pressure at which oxygen reading was obtained (BFP). **Calculate** the oxygen remaining using the formula at left.

$$\text{Remaining Oxygen \%} = \frac{\text{BFAV x BF}}{\text{PTCP}}$$

4.5.10.2 *When the test environment pressure is above 14.7 psia*, **vent** the test chamber to 14.7 psia by pressing the **VENT** ECV control button. **Press** the **VENT** ECV control button again once a chamber pressure of ambient 14.7 psia is reached. **Open** the **OXYGEN ANALYZER** ECV.

4.5.10.3. **Report** the remaining oxygen concentration value in the appropriate block of the test data sheet.

4.5.11. **Return** the chamber to an ambient O_2 concentration of 21% or less:

- **Open** the chamber vent by pressing the **VENT** button.
- **Begin purging** the chamber with nitrogen by pressing the **NITROGEN** button.
- **Turn on** the fans by pressing the **FANS** button.

- When an O_2 concentration of 21% or less is achieved, **stop** the nitrogen flow, stop the O_2 analyzer chamber sampling, **turn off** the fans, and **shut** the vent.

4.5.12. **Evacuate** the test chamber.

- **Open** the vacuum valve by pressing the **VACUUM** button.
- **Turn on** the vacuum pumps by pressing the vacuum pumps START button.

After achieving maximum vacuum, **open** the test chamber vent ECV, and **turn off** the vacuum ECV and the vacuum pump. **Don** all necessary personal protective equipment, *i.e.*, gloves, safety glasses, clean laboratory jacket, respirator, *etc.*

4.5.13. Before opening the test chamber, **ensure** that the test chamber is at ambient pressure (14.5 psia) and the test chamber temperature is below 100 ˚F. *If the temperature is above 100 ˚F*, **wear** leather heat-resistant gloves while handling the sample and test stand. **Verify** temperatures by the thermocouple readouts on the Main Control Panel. To open the door of the small test chamber, **set** the chamber door actuator lever to the open position (down), and **apply** power to the hydraulic pump until the rotating clamp is completely disengaged from the test chamber door. For the large test chamber, **pull** the safety lock back, and **power** the drive motor until the clamps have moved sufficiently to open the door. Moving the switch up opens the door clamps.

4.5.14. **Remove** the tested sample, **allow** it to cool, and **repackage** it in the original sample storage bag. If needed, **clean** the test chamber, and **vacuum out** any ashes or residue resulting from the test run. The vacuum cleaner used shall have a solid tank, and all solid waste shall be disposed of in the appropriate manner. Also, **clean** all port windows, if necessary, using a lint-free cloth and glass cleaner (NSN 7930-010-064-5179). These two procedures and other weekly and biweekly maintenance **shall be performed a**fter any test that produced excessive amounts of soot or other residue. *If the K-10 paper was damaged in any way or is dirty from other sources and is not easily cleaned off,* **replace** it with a new piece of K-10 paper. **Repeat** steps 4.4.5 through 4.5.14 for each test sample until the test is complete (usually three samples per oxygen concentration/pressure combination for Test 1 and one test sample per oxygen concentration/pressure combination for Test 8 and Test 10).

Note: *If thresholding is requested on the test request*, **follow** the Thresholding Guidelines in section 4.7. X-code materials, however, **shall not be** threshold tested unless specifically requested by the test requester.

4.5.15. Upon completion of the test request (all testing specified in the test plan for that work folder), **turn off** the facility warning beacon, and **verify** that the correct test environment for each set of samples is listed on the post-test sample

package. **Ensure** that the sample number of the repackaged samples corresponds to the order in which the samples were tested. *If any samples remain that were prepared but not tested*, **remove** them from the prepared sample storage cabinet, and **place** these samples with the post-test samples in the sample preparation area for archival purposes.

4.5.16. **Perform** data recording and post-test photography in accordance with section 4.9.

4.6 Special Test Procedures

The *test operator* s**hall perform** the following procedures:

4.6.1. Samples Requiring Pre-Heat

4.6.1.1. For preheated flammability test samples, **follow** steps 4.4.1 through 4.4.10 for system setup and sample loading. The small heating chamber (Figure 15, section 9.1) is used to pre-heat all samples. **Position** a thermocouple so that the thermocouple tip touches the sample material itself (not the substrate), being sure that the thermocouple tip **does not impede** the flame front. *If physically possible,* the heat source shall encompass the entire sample whenever possible. After configuring the heat source and positioning thermocouples, **complete** steps 4.4.11 through 4.4.16 for system setup and sample loading.

4.6.1.2. After the sample has been loaded and the chamber has been prepared for testing, **follow** steps 4.5.1 through 4.5.6 in the detailed test procedure. Concurrently with step 4.5.6, **initiate** the heating of the sample. **Record** the time elapsed for the sample to achieve the desired pre-heat temperature. **Expect** the time to be unavoidably longer than the minimum 3-minute soak. **Record** this information in the Remarks section of the test data sheet for each sample. **Maintain** the pre-heat temperature within ±5% of the requested temperature, unless instructed otherwise on the test plan for that material. **Clearly explain** any deviations in the Remarks section of the test data sheet.

4.6.1.3. After the sample is pre-heated, **continue** with steps 4.5.7 through 4.5.9 in the detailed test procedure. After the sample has extinguished completely, **turn power off** to the heater. **Conclude** the flammability test by following steps 4.5.10 through 4.5.16 in the detailed test procedure.

4.6.2. Smolder Tests

For foams or fibrous materials, **follow** the steps in the system setup and sample loading section. **Proceed** with testing by following steps 4.5.1 through 4.5.9 in the test procedure. After step 4.5.9, *if the test sample did not burn more than 6*

in., **continue to monitor** the test for 10 minutes after the sample extinguishes to determine if the sample material is smoldering. *If the sample was preheated*, **continue heating** until monitoring of the sample is complete. *If the charred area of the sample seems to increase,* **begin recording** the sample again. *If the sample does smolder*, **monitor** the test until the creeping char line ceases to move. This shall be considered part of the burn time; however, **document** the time of visible flame/glow in the Remarks section of the test data sheet as well. **Stop** the video recording once the char creep has stopped. **Conclude** the flammability test by following steps 4.5.10 through 4.5.16 in the test procedure.

4.6.3. Combustion By-Products Sampling

4.6.3.1. *If a combustion by-products sample is requested for this test at or below 14.7 psia*, **follow** the steps outlined in the system setup and sample loading section. After completing step 4.4.16, **install** a combustion by-products sample chamber on the test chamber at an available access port. The combustion by-products sample chamber is typically an evacuated 3-liter (approximately) chamber fitted with a valve and an AN-type fitting. **Acquire** the chambers from the Toxicity Laboratory in Room 100, as needed.

4.6.3.2. After the by-products chamber has been installed, **continue** the test by starting with steps 4.5.1 through 4.5.9 in the detailed test procedure. At the conclusion of the burn, **turn on** the chamber fans for 2 to 5 minutes, then **open** the valve on the combustion by-products chamber, and **allow** the pressure in the sample by-products chamber to equalize with the test chamber (approximately 30 seconds). **Close** the valve on the by-products chamber. **Turn off** the test chamber fans.

4.6.3.3. **Continue** the detailed test procedure through step 4.5.12. Before opening the test chamber, **disconnect** the combustion by-products chamber from the test chamber, and **cap** the open line to the test chamber. **Tag** the canister with the request number, test environment, sample material name, test date, and write *combustion by-products* on the label. **Note** on the test data sheet from which sample number, *i.e.*, 1, 2, or 3, the combustion by-products were drawn. **Deliver** the by-products chamber to the Toxicity Laboratory with a copy of the test request for this material and the MSDS for the tested material. **Complete** the flammability test by following steps 4.5.13 through 4.5.16 in the detailed test procedure section.

4.7 Thresholding Guidelines

This section establishes thresholding procedures for standard upward propagation tests. Thresholding is defined in this document as (a) the process for determining the oxygen concentration at which the tested material burns 6 inches or more or (b) the oxygen level below which the tested material is rated A. **Always follow the**

test plan. These instructions are not meant to supersede instructions provided on the signed test plan.

4.7.1. Part 1: For test requests that have multiple sets of flammability test samples supplied, the following thresholding procedures shall be used. Thresholding a material by inverting a set of samples that has already been tested is acceptable laboratory practice providing that the initial burn's **total burn length and heat-damaged/permanently discolored area on each test sample is less than 3 in.** All sample sets must undergo one burn event including post test photographs prior to any sample being inverted and exposed to a second burn. No more than three thresholding steps shall be performed.

4.7.1.1. Section 1: For materials tested at 20.9% oxygen concentration:

- *If there is a moderate or large drip burn,* **stop** testing.
- *If material burns less than 1 in.,* **test** at 30% oxygen. [**See** section 4 (paragraph 4.7.1.4.) of this procedure.]
- *If material burns more than 1 in. but less than 3 in.,* **test** at 25.9% oxygen. [**See** section 3 (paragraph 4.7.1.3.) of this procedure.]
- *If material burns more than 3 in. but less 6 in.*, **test** at 23.8%/24.1% oxygen. [**See** section 2 (paragraph 4.7.1.2.) of this procedure.]
- *If the material burns more than 6 in.*, **stop** testing..

4.7.1.2. Section 2: For materials tested at 23.8%/24.1% oxygen concentration:

- *If there is a moderate or large drip burn,* **test** at 20.9% oxygen.
- *If material burns less than 1 in.*, **test** at 34% oxygen. [**See** section 5 (paragraph 4.7.1.5) of this procedure.]
- *If material burns more than 1 in. but less than 3 in.*, **test** at 30% oxygen. [**See** section 4 (paragraph 4.7.1.4.) of this procedure.]
- I*f material burns more than 3 in. but less than 6 in.,* **test** at 25.9% oxygen. [**See** section 3 (paragraph 4.7.1.3.) of this procedure.]
- *If material burns more than 6 in.*, **test** at 20.9% oxygen.

4.7.1.3. Section 3: For materials tested at 25.9% oxygen concentration:

- *If there is a moderate or large drip burn,* **test** at 23.8%/24.1% oxygen. [**See** section 2 (paragraph 4.7.1.2.) of this procedure.]
- *If material burns less than 1 in.,* **test** at 40% oxygen. [**See** section 6 (paragraph 4.7.1.6) of this procedure.]
- *If material burns more than 1 in. but less than 3 inc.,* **test** at 34% oxygen. [**See** section 5 (paragraph 4.7.1.5) of this procedure.]
- *If material burns more than 3 in. but less than 6 in.,* **test** at 30% oxygen. [**See** section 4 (paragraph 4.7.1.4.) of this procedure.]
- *If material burns more than 6 in. but less than 10 in.,* **test** at 23.8%/24.1% oxygen. [**See** section 2 (paragraph 4.7.1.2.) of this procedure.]
- *If material burns more than 10 inches,* **test** at 20.9%. [See section 1 (paragraph 4.7.1.1) of this procedure.]

4.7.1.4. Section 4: For materials tested at 30% oxygen concentration:

- *If there is a moderate or large drip burn,* **test** at 25.9% oxygen. [**See** section 3 (paragraph 4.7.1.3.) of this procedure.]
- *If material burns less than 1 in.,* **test** at 50% oxygen. [**See** section 6 (paragraph 4.7.1.6) of this procedure.]
- *If material burns more than 1 in. and less than 3 in.,* **test** at 40% oxygen. [**See** section 6 (paragraph 4.7.1.6) of this procedure.]
- I*f material burns more than 3 in. and less than 6 in.,* **test** at 34% oxygen. [**See** section 5 (paragraph 4.7.1.5) of this procedure.]
- *If material burns more than 6 in. but less than 10 in.,* **test** at 25.9% oxygen. [**See** section 3 (paragraph 4.7.1.3.) of this procedure.]
- *If material burns more than 10 in.,* **test** at 23.8%/24.1% oxygen. [**See** section 2 (paragraph 4.7.1.2.) of this procedure.]

4.7.1.5. Section 5: For materials tested at 34% oxygen concentration:

- I*f there is a moderate or large drip burn,* **test** at 25.9% oxygen. [**See** section 3 (paragraph 4.7.1.3.) of this procedure.]
- *If material burns less than 3 in.,* **test** at 50% oxygen. [**See** section 6 (paragraph 4.7.1.6) of this procedure.]
- *If material burns more than 3 in. but less than 6 in.,* **test** at 40% oxygen. [**See** section 6 (paragraph 4.7.1.6) of this procedure.]
- *If material burns more than 6 in. but less than 10 in.,* **test** at 30% oxygen. [**See** section 5 (paragraph 4.7.1.5) of this procedure.]
- *If material burns more than 10 in.,* **test** at 25.9% oxygen. [**See** section 4 (paragraph 4.7.1.4) of this procedure.]

4.7.1.6. Section 6: For materials tested at 40% oxygen concentration or greater:

- *If there is a moderate or large drip burn,* test at 25.9% oxygen. [**See** section 3 (paragraph 4.7.1.3.) of this procedure.]
- *If material burns less than 6 in.,* test at 50% oxygen.
- I*f material burns more than 6 in.,* test at 34% oxygen. [**See** section 5 (paragraph 4.7.1.5) of this procedure.]

4.7.2. Part 2: For test requests that have one set of flammability samples supplied, the following thresholding procedures shall be used. Thresholding a material by inverting a set of samples that has already been tested is acceptable laboratory practice, providing that the initial burn **total burn length and heat damaged/ permanently discolored area on each test sample is less than 3 in.** All sample sets shall undergo one burn event, including post-test photographs before any sample is inverted and exposed to a second burn. No more than three thresholding steps shall be performed.

4.7.2.1. Section 1: For materials tested at 20.9%, 23.8%, or 24.5% oxygen concentration:

- *If there is a moderate or large drip burn*, **stop** testing.

- *If burn length and heat-damaged/permanently discolored areas are less than 3 in.*, **invert** the sample, and **test** at 25.9% oxygen.

4.7.2.2. Section 2: For materials tested at 25.9% oxygen concentration:
- I*f there is a moderate or large drip burn,* **test** at 20.9% oxygen.
- *If burn length and heat-damaged/permanently discolored areas are less than 3 in.,* **invert** the sample, and **test** at 30% oxygen.

4.7.2.3. Section 3: For materials tested at 30% oxygen concentration:
- *If there is a moderate or large drip burn,* **test** at 25.9% oxygen.
- *If burn length and heat-damaged/permanently discolored areas are less than 3 in.,* **invert** the sample, and **test** at 40% oxygen.

4.7.2.4. Section 4: For materials tested above 30% oxygen concentration:
- *If there is a moderate or large drip burn,* **test** at 25.9% oxygen.
- *If burn length and heat-damaged/permanently discolored areas are less than 3 in.*, **invert** the sample, and **test** at 50% oxygen.

4.8 Shutdown Procedure

Perform the tester shutdown procedure at the end of each work shift. **Completely clean** the test chamber, **place** supplies and tools in the appropriate storage locations, **close** all valves, **fully reduce** regulators, **power off** power supplies and the control console, and **secure** the work area. **Wear the appropriate safety gear** during these operations. The tester shutdown procedure is:

1. Clean all windows/view ports.
2. Clean all sample holders and test stand equipment.
3. Place tools in the appropriate areas.
4. Close all gas bottles for the test cell.
5. Vent all supply lines from the bottle farm to the test chamber.
6. Close valves on gas supply lines at the chamber once all supply lines are vented.
7. Switch all ECVs off.
8. Replace any empty gas bottles.
9. Sweep test chamber area.
10. Ensure that all video camera equipment is secured and powered down.
11. Power down the control panel, VCR(s), monitor(s), oxygen analyzer pump and valves, test cell ventilation fan, and all test cell lights.
12. Close and secure all outside doors.

4.9 Data Recording and Reduction; Post-Test Photography

The *test operator* **shall perform** the following procedures:

4.9.1. Data Recording and Reduction

4.9.1.1. **Remove** the test sample from the chamber, and **weigh the** sample. Place this value in the *Post-test Sample Weight* field of the test data sheet. *If the sample was consumed totally and could not be weighed,* **write** N/A in the post-test sample weight field, and **note** this in the Remarks section of the test data sheet.

4.9.1.2. **Measure** the burn length of the sample tested. **Determine** the burn length to the nearest 0.1-in. increment. Any portion of the sample that is distorted or discolored from exposure to heat but that did not burn is not to be included in the final burn length determination. **Write** comments in the Remarks section of the test data sheet to describe any occurrences of distorted material caused by heat exposure.

4.9.1.3. **Determine** igniter burn time from the test video. **Record** this time in the appropriate field on the data sheet. *If the igniter burn time could not be determined,* **write** U (*Undeterminable*) in the appropriate field, and **note** why in the Remarks section of the data sheet.

4.9.1.4. **Determine** the burn propagation time by reviewing the test video. **Write** this value in the appropriate field.

4.9.1.5. **Calculate** the propagation rate of the test sample by dividing the burn length by the burn propagation time. **Record** this value in the appropriate field on the test data sheet to the third decimal place, *i.e.*, 0.0033 in./sec becomes 0.003 in./sec; 0.0058 in./sec becomes 0.006 in./sec.

4.9.1.6. **Determine** the total burn time from the test video. Do not include the burn time of the K-10 paper. **Write** this value in the proper field on the test data sheet.

4.9.1.7. **Fill** in the fields on the test data sheet pertaining to drip burning, sparks and flame jets. **Review** the video to verify all observations. **Comment** on any unusual observations and/or sample burn behavior in the remarks section of the test data sheet (unusual flame color, material propagation halted upon removal of ignition source, chamber pressure increase during test, sudden extinguishing of sample, unique burn paths, total consumption, etc.).

4.9.1.8. **Inspect** the K-10 paper (*if used during the test*) for any signs of scorching, burn spots, etc., and **note** in the remarks section of the test data sheet

the severity of the burn(s). *If the K-10 paper ignited,* **place** a **Y** in the K-10 field of the test data sheet; otherwise, an **N** is to be placed there.

4.9.1.9. For Test 8 or Test 10, **record** the results of the test as described above. In addition, diagonal and horizontal burn lengths and propagation rates **shall** also be determined, where applicable. Also, the comments for these tests **shall** be very descriptive as to configuration of the sample, layout, sample mounting in the test stand, igniter placement, burn characteristics, *etc*.

4.9.1.10. **Sign** and **date** the test data sheet before closing out the test folder.

4.9.1.11. **Give** the completed work folder to the test engineer.

4.9.2. Post-test photographs **shall** be taken of each sample tested. Each photograph shall be labeled with the request number, test environment, and sample number. The sample shall be arranged so that the total burn length is visible in the photograph. A scale **shall** be included to assist in documenting the burn length. **Include** three copies of each photo in the test folder. When engaged in research testing a typical post-test photographic representation of a burn is acceptable. Clarification of photographic documentation shall be provided by either the test engineer or the test requestor. **Refer** to the *Photography Operating Guide* for instructions on camera operation. Photographs shall be retained indefinitely.

5.0 Notes

Custodians for EM10-OWI-CHM-034	
Master List and Document Control	EM10 Management Support Assistant
Alternate Document Control	EM10 Group ISO Representative
Records	Materials Test Branch ISO Representative
Calibration	Materials Test Branch Calibration Contact
Memoranda	Materials Test Branch ISO Representative

6.0 Safety Precautions and Warning Notes

6.1 Hazards

Warning
Death, severe personal injury, or loss of major equipment may result if maintenance or operating procedures, techniques, restrictions, etc., are not followed exactly.

Because of the nature of testing with flammable materials under high and low pressures, the testing system involves several hazards to the operator and facility. These include:

- Evacuation and pressurization of the flammability chambers
- Burning materials in air or oxygen-enriched environments
- Systems pressurized with nitrogen and oxygen
- Electrical load and other ignition sources applied in air, oxygen-enriched environments, and combustible by-products
- Flammable and dangerous liquid solvents
- Heavy parts of the test apparatus handled and moved on a regular basis,
- Electrical valves, power supplies, switches, and other components
- Combustion by-products
- Oxygen deficiency.

6.2 Safety Precautions

6.2.1. Personnel **shall plan** testing so at least one test operator is in the test area and one other person is in Building 4623 during normal business hours. After normal business hours and on weekends, a test engineer **shall** be in Building 4623 during all test activities. **No more than 5 persons** shall be in the test cells at any one time. Operation of the tests shall comply with EM10-OWI-CHM-050, *Building 4623 Guidelines for Test Operations.*

6.2.2. Controls **shall not be operated** when personnel are working with the test chamber. A sign warning that personnel are working in the test cell shall be **placed** on the control console. All pressure leak checks **shall be performed** at or below 25 psia with an inert gas.

6.2.3. Personnel **shall wear** safety apparel appropriate for the test specimens and conditions, referring to the MSDS for information on the personal protective equipment for the materials being handled (sample materials, solvents, *etc.*). Personnel **shall wear:**

- Safety shoes when there is a danger of foot injuries from falling or rolling objects, objects piercing the sole of the shoe, or when feet may be exposed to an electrical hazard
- Clean laboratory jacket when working with enriched oxygen or other oxidizers, combustion by-products, compressed gases, or flammable solvents
- Safety glasses at all times when in the test cell

- Chemical goggles and gloves while cleaning test equipment and while working with solvents.
- A respirator when working with solvents in closed or poorly ventilated spaces. The appropriate respirator shall be worn as indicated on the solvent's MSDS. The cartridge respirators are only good for the constituents listed on the filtration cartridge and for dust particle filtration. Supplied air respirators may be required for exposure to certain chemicals. **Personnel shall be qualified to use a respirator, and the respirator shall be supplied by MSFC.**

6.2.4. **Smoking shall not be permitted** in Building 4623. Personnel shall **not smoke or expose clothing** to an open flame for a period of 30 minutes after exposure to solvents and oxygen-enriched gases.

6.2.5. The building warning system shall be activated for the duration of all testing, including pre- and post-test procedures such as leak checks, purges, or verification of the igniter power source.

6.2.6. Nothing **shall be stored** in the test cells other than parts or components of the testing apparatus and the tools necessary for equipment maintenance. All other materials **shall be removed** from the test cells and spare equipment placed in labeled cabinets or shelves for adequate inventory and access.

6.2.7. Personnel **shall know** the location of all the safety eyewashes, showers, and fire extinguishers inside and outside the test area.

6.2.8. All testing **shall be performed remotely**. The control console **shall be staffed continuously** during all testing activities and remotely controlled processes. No one **shall be** allowed inside the test cells during the following test processes or conditions:

- Power on to the igniter system
- Burning or glowing of the sample
- Venting of the chamber
- Filling or evacuating the chamber
- Whenever the small chamber is pressurized above 25 psia.

6.2.9. **The burst disk rating for the Small Flammability Chamber is set at 55 psia.** This setting is based upon the vacuum gate valve being rated for 67 psig and the port window glass being rated for 70 psia. The design analysis performed by Teledyne Brown Engineering in April 1997 rated the small chamber itself for 139 psig; therefore, it is possible to increase the setting of the burst disk if the vacuum gate valve and port window glass are changed. **The maximum pressure for the Large Flammability Chamber has been determined to be 14.7 psia.**

6.2.10. **Do not use the vacuum pumps to vacuum down an enriched-oxygen atmosphere.** They are not compatible with enriched or gaseous oxygen. The pumps are used to reduce test pressure slightly from filling to as low as 10.2 psia. This is acceptable; however, the pumps **shall not be used** to pull a vacuum on the system unless it has been purged.

6.2.11. Oxygen-deficiency alarms are located throughout the building. When an oxygen-deficiency alarm sounds, all personnel **shall evacuate** from the immediate area and **notify** security and supervisors. Personnel **shall call 4-4357 (4-HELP) and then press 1 to notify security.**

6.2.12. Personnel **shall ensur**e that all electrical components, wiring, *etc*., are in **good condition** and **properly grounded**. In addition, no electrical devices **shall** be operated when floors in the test cell are wet.

6.2.13. Personnel **shall equalize** test chamber pressure to ambient before opening. In addition, *if the tested material ignited*, the chamber shall be purged with nitrogen, **evacuated**, then **vented** to remove most of the nitrogen gas before opening. **Whenever nitrogen is used, the interior of the test chamber may be *oxygen deficient* and *may not support respiration*.**

6.2.14. Personnel **shall ensur**e that the igniter power source is **off** before entering the test cell.

6.2.15 When handling cylinders and dewars or when making connections for compressed gases and/or liquids, personnel **shall refer** to *Working Safely with Compressed Gases and Cryogens* and *NSTC 313-Cryogenics Safety.* and shall **comply** with the suggestions inside these presentations. (The test engineer has these resources.)

6.2.16. The Emergency Shutdown Procedure (section 6.4) shall be posted in view of the tester console.

6.2.17. The building warning lights **shall be checked** daily for proper operation.

6.3 Special Precautions Associated with Compressed Gases and Liquids

6.3.1. All operations involving compressed gases and liquids shall be conducted using the buddy system.

6.3.2. All operating personnel shall be instructed on the nature of hazards associated with compressed gases and liquids.

6.3.3. Before removing any component of the system for servicing, the *operator* **shall secure** and **inspect** the system to ensure that no unsafe condition exists.

6.3.4 Personnel **shall perform** continuous monitoring, *e.g.,* check operating pressures, look for leaks, listen for unusual noises, during all operations. Personnel **shall ensure** that oxygen leak levels are adequate throughout operations.

6.4 Emergency Shutdown Procedure

The *test operator* **shall shut down** the test equipment in case of an emergency. *If the operator cannot do so*, *any person* **may read** the posted emergency shutdown procedures and **shut down** the equipment. The *test operator* **shall also notify** the lead test engineer of the emergency shutdown. The test operator **shall perform** the following procedures:

6.4.1. Small Flammability Chamber

6.4.1.1. **Press** the **POWER** button on the control console. This deactivates all electrical components except the VCR and monitors. This procedure turns off all gases to the chamber (although the gas lines remain pressurized) and opens the vent.

6.4.1.2. **Press** the **red** shutdown button located to the rear of the console on the panduit on the south wall of Room 126. This deactivates the power to the vacuum pumps.

6.4.1.3. **Deactivate** the facility oxygen line by depressing the **Emergency Stop Oxygen Supply** button located on the side of the Oxygen Supply Master Control Panel. The Oxygen Supply Master Control Panel is located directly adjacent to and just inside of the west exit of Building 4623. **Deactivate** the facility nitrogen line by turning the Supply Regulator Control Knob (GNR9-4623) fully counterclockwise. This control is located on the GN_2 Purge Panel/ Flammability Panel on the east side of the facility near the back door.

6.4.2. Large Flammability Chamber

6.4.2.1. **Press** the **POWER** button on the flammability chamber control console. This deactivates all electrical components except the VCR and monitors. This step turns off all gases to the chamber (although the gas lines remain pressurized) and opens the vent.

6.4.2.2. **Deactivate** the facility oxygen line by depressing the **Emergency Stop Oxygen Supply** button located on the side of the Oxygen Supply Master Control Panel. The Oxygen Supply Master Control Panel is located *directly* adjacent to and just inside of the west exit of Building 4623. **Deactivate** the

facility nitrogen line by turning the Supply Regulator Control Knob (GNR9-4623) fully counterclockwise. This control is located on the GN2 Purge Panel/ Flammability Panel on the east side of the facility near the back door.

6.5 Accident Reporting

6.5.1. From a safe location, the *test operator* **shall call 911 immediately** and **notify** the EM10 Branch Chief.

6.5.2. From a safe location, the *EM10 Branch Chief* **shall immediately report** the accident to the NASA Safety Monitor and the appropriate supervisor(s).

6.6 Emergency Response Plan

Emergency procedures and plans for Building 4623 are incorporated into this OWI and are stated in MPR 1040.3G, *MSFC Emergency Plan.* Plans **shall be modified** if operations change in a significant manner.

6.7 Mishap Reporting

Report all mishaps occurring in Building 4623 to the test engineer, who shall report the mishap to the area coordinator/Safety Monitor. An initial verbal report **shall** be made within 8 hours, followed by a written report within 3 days. The *EM10 Branch Chief* **shall prepare** a managerial report within 7 days. Both reports **shall** be reviewed by the test operator's supervisor and by the NASA Safety Monitor. The detail and extent of the mishap report **shall** depend on the nature and extent of the damage. *If personnel injury or equipment damage does occur,* the mishap report **shall** be completed in accordance with MWI 8621.1, *Close Call and Mishap Reporting and Investigation Program.*

7.0 Attachments, Data, Reports, and Forms

7.1 Attachments

The test operator **shall perform** the following procedures:

7.1.1. Operating Instructions for the Panasonic® Character Generator

The title format is normally saved in the character generator and the only requirement is to edit the sign from one test to the next.

7.1.1.1. To edit the sign, the mode selection switch (at the top of the generator board directly to the right of Panasonic® model number) **shall be set** on **EDIT TITLE**. This displays the title on the video monitor. **Move** the cursor (by the arrow keys) until the desired editing position is reached. **Type** the necessary changes from the keyboard. To delete a character, **press** the **DELETE** button located on the far right side of the second row. To add a space, **press** the **SPACE** button located in the center of the board at the bottom. No further editing operations are necessary. **Refer** to the *Panasonic® Character Generator WJ-TTL5 Operating Instructions* for additional information.

7.1.1.2. To record the sign on the tape, the mode selection switch shall be set to **REC TITLE**. This displays the title on the screen, and the extraneous editing marks disappear. **Record** the screen by pressing **RECORD** on the VCR. **Record** this screen for approximately 10 seconds. After the sign is recorded, **stop recording** until the end of the test sample soak time, as described in section 4.5.6.

Note: The recording can be the last 10 seconds of the test sample soak time. After the sign is recorded, **remove** the test title by selecting the **STOPWATCH** selection. **Allow** the recording to continue if all pre-ignition test conditions are satisfied and igniter ignition is about to be initiated.

7.1.1.3. To operate the stop watch, the mode selection switch shall be set to **STOPWATCH**. **Press** the **START/STOP** button to start the stop watch function. This button is located in the left corner at the bottom of the board. **Press** the **START/STOP** button to stop the stop watch. **Hit** the **LAP/RESET** button to reset the stop watch time. The **LAP/RESET** button is located on the far left side of the board in the third row.

7.1.2. Igniter Storage and Verification Information

7.1.2.1. The chemical igniters are currently purchased from the White Sands Test Facility. Each individual igniter is 0.125 in. in diameter and is 1 (±0.25) in.

long. Upon receipt, **verify** each shipment of chemical igniters by testing 10 igniters. The steps for this testing are:

7.1.2.1.1. **Use** a *new* nichrome 70 igniter wire (20 AWG) cut 6.5 in. in length. The igniter wire shall wrap around the length of the igniter three equally spaced turns (Figure 8) with approximately equal lengths of wire left at each end for clamping into the test fixture.

7.1.2.1.2. **Mount** the igniter unit onto a standard test stand.

7.1.2.1.3. **Secure** two or more Type K thermocouples approximately 0.25 in. above the igniter. An accepted alternative is to use an infrared thermometer instead of the thermocouples or along with the thermocouples.

7.1.2.1.4. **Evacuate** the test chamber, and **follow** the same environmental gas mixing strategy for an actual test, bringing the test chamber to 14.7 psia and 20.9% O2. **Initiate** power to the igniter, **turn power off** when igniter ignites, and then **record** the following:

- Maximum temperature achieved
- Total burn time
- Maximum flame height.

7.1.2.1.5. **Repeat** these steps until all 10 igniters have been tested.

7.1.2.2. The above verification results shall meet the following criteria:

- Temperature shall be 2000(±160) ˚F
- Burn time shall be 25 (±5) seconds
- Flame height shall be 2.5 (±0.25) in. As an exact measurement is not possible, a rating of good or bad is acceptable.

7.1.2.3. **Store** the chemical igniters in a desiccator with a humidity gauge. When the humidity in the desiccator is above 30%, **replace** the desiccant. The humidity in the desiccator **shall be monitored** daily.

7.1.2.4. The silicon igniters, used in atmospheres above 40% oxygen, are made at MSFC by ED34. Each batch of silicon igniters shall be verified in much the same manner as the chemical igniters. Exceptions to the above procedure are that 5 igniters shall be tested at 50% O_2, 10.2 psia, and 18-gauge wire shall be used in place of 20 gauge. The same measurements shall be recorded; however, silicon igniter performance characteristics are not the same as that of chemical igniters.

7.1.2.5. The silicon igniters are prepared according to the following procedure:

7.1.2.5.1. **Blend** 82.5 parts by weight of RTV-560 or equivalent with 17.5 of RTV-577 or equivalent. To the mix, **add** 0.5 parts by weight of Thermolite T-12, and **mix thoroughly. Immediately de-aerate** the blend in a vacuum of not less than 28-in. mercury for a period of not more than 10 minutes. Then **cast** the compound in a mold that **shall** provide cured and finished rods of 0.22 in. diameter and 1.25 in. length.

7.1.2.5.2. **Cure** the compound either for 24 hours at room temperature or for 4 hours at room temperature followed by 10 hours at 130 $\pm$10 ˚F. The cured material shall show a Shore A durometer reading of not less than 40.

7.1.2.6. A copy of each set of igniter verification test results shall be kept in the *Small Flammability Tester Maintenance Log.*

7.1.3. Process for Post-Fill Mixing Enriched Oxygen for Flammability Testing

7.1.3.1. Purpose: To generate the appropriate oxygen concentration at the corresponding test pressure via partial pressures of oxygen and nitrogen in the test chamber.

7.1.3.2. Calculation: The purity of oxygen to be added initially **shall** be known to calculate the appropriate gas pressures.

7.1.3.3. With these considerations, the following equation **shall** determine the partial pressure of oxygen to be introduced to the chamber for the appropriate test environment (using constant volume and assuming pure nitrogen):

Equation for oxygen concentration in test chamber

$$P_{oxygen} = \frac{[Y_{env} \times P_{amb}] + [0.209 \times P_{resid}]}{C_{oxygen}}$$

P_{oxygen}	Pressure (psia) of oxygen to add to the chamber to obtain the test environment oxygen concentration
Y_{env}	The oxygen concentration of the proposed test environment in decimal notation (i.e., 25.9% = 0.259)
P_{amb}	Chamber pressure (14.7 psia)
P_{resid}	Residual pressure left in the test chamber after vacuum
C_{oxygen}	Decimal value of the concentration of oxygen being used

Note: This calculation is only valid when using N_2 containing only trace amounts of oxygen.

7.1.3.4. Mixing Process

7.1.3.4.1. After calculating the partial pressure for the proposed test environment, **initiate** mixing. **Turn on** the fans in the test chamber. **Flow** the oxygen in first until the pressure gage reads 30% of the calculated partial pressure. For example, if the calculated partial pressure is 3.8 psia using 100% oxygen, **flow** the 100% oxygen in until the pressure gauge reading increases by 1.2 psia.

7.1.3.4.2. The total partial pressure of nitrogen needed to reach a chamber pressure of 14.7 psia (after all the oxygen has flowed in) shall be 10.9 psia. **Backfill** the chamber with nitrogen until the pressure gauge reads 30% of the calculated partial pressure for nitrogen; the pressure gauge reading increases by 3.3 psia. **Repeat** this alternating pattern until a total of 3.8 psia oxygen and a total of 10.9 psia nitrogen has flowed into the chamber. The chamber pressure shall be 14.7 psia. This alternating pattern is helpful in the mixing of the oxygen and nitrogen gases. Upon adding all the oxygen and nitrogen, **turn on** both the large and small fans in the test chamber to allow the gases to reach equilibrium. After five minutes, **turn off** the fans. **Resume** standard procedures at step 4.5.3.

7.2 Forms

Figures 9, 10, and 11 are representative of the forms that are used in performing flammability testing.

Flammability Tests 1, 8, and 10 Pre-Test Checklist

Request No. _____

Initial

1. [ ] NASA-STD-6001 reviewed?
2. [ ] Flammability OWI reviewed?
3. [ ] All safety equipment available and working properly?
4. [ ] Test equipment checked out per OWI?
5. [ ] Sufficient gas supply pressure to pressurize chamber properly?
6. [ ] Test material's MSDS read?
7. [ ] Test plan read and changes noted and approved by engineer?
8. [ ] Pre-test photos taken?
9. [ ] If this is a configuration sample, placement of igniter is documented and approved by test engineer?
10. [ ] Enough igniters to complete the test?
11. [ ] Facility warning beacon activated?

Oxygen/Pressure Verification

1st test	_____ O2 _____ PSIA	**2nd test**	_____ O2 _____ PSIA	**3rd test**	_____ O2 _____ PSIA
	_____ O2 _____ PSIA		_____ O2 _____ PSIA		_____ O2 _____ PSIA
	_____ O2 _____ PSIA		_____ O2 _____ PSIA		_____ O2 _____ PSIA
4th test	_____ O2 _____ PSIA	**5th test**	_____ O2 _____ PSIA	**6th test**	_____ O2 _____ PSIA
	_____ O2 _____ PSIA		_____ O2 _____ PSIA		_____ O2 _____ PSIA
	_____ O2 _____ PSIA		_____ O2 _____ PSIA		_____ O2 _____ PSIA

_____ _____

Test operator signature Date

1/05 EM10-F-CHM-011

Figure 9.
Typical Flammability Pre-test Checklist.

Note: Representative pre-test checklist. Refer to Forms Master list for current version.

Figure 10.
Typical Flammability Test Data Sheet.

Test 1 Flammability Test Data Sheet

Project:_____ Date:_____ Test No.:_____
Request ID No.:_____ Requester:_____
Lot No.:_____ Set No.:_____ Batch No:_____
Manufacturer Designation:_____
Manufacturer:_____
Composition:_____
Specification:_____
Request Pressure:_____(psia) Chamber Volume:_____(cu. ft.)
Request O_2 Percent:___ Percent 2nd Gas:___ Name 2nd gas:_____
Substrate Thickness:_____(in.) Substrate Weight:_____ (g)
Substrate Material:_____

Cure Time	Cure Temp (F)	Cure Pressure	Preheated Sample Temp (F)
_____	_____	_____	
_____	_____	_____	_____
_____	_____	_____	

Test No.: 1 (up) _____
Nonstandard _____
Configuration _____
Smolder _____

Tape No.:_____
Storage CD No.: _____

Observations (None, Small, Mod, Large)

Samp #	Width (in.)	Length (in.)	Thick/ Dia. (in.)	Burn Length (in.)	Total Burn Time (s)	Upward Burn Time (s)	% Oxy. Rem.	Prop Rate (in./s)	K-10 (Y/N)	Flame Jets	Sparks	Drip Burn
1.												
2.												
3.												

Samp #	Oxy. % Reading	Test Press. (psia)	Video Start Frame #	Sample Wt. (g)	Total Wt. Before (g)	Total Wt. After (g)	Ing. Burn Time (s)
1.							
2.							
3.							

Test Chamber Temperature:
Pre-test #1 _____F Post-test #1 _____F
Pre-test #2 _____F Post-test #2 _____F
Pre-test #3 _____F Post-test #3 _____F

Excess Sample: ☐ Y ☐ N
Quantity of Excess _____
Storage Box _____

Test Conductor _____
Remarks _____
1/05 EM10-F-CHM-010

Note: Representative flammability test data sheet. Refer to Forms Master list for current version.

Calibration Statement: Categories IV and V Equipment

Calibration is required before use per MPR-8730.5.

(Calibration before use for each test series and periodic testing by the Using LIne Organization)

Calibration Contacts: EM10/James Perkins, EM10/Mark Griffin

User Name:_____

Equipment Description:_____

(attach multiple components sheets if necessary)

Manufacturer:_____

ECN:_____ Serial No.:_____ Model No.:_____

Date of Calibration:_____

Type of Software and Version:_____

_____

Listing of Standards Associated with Calibration:

_____

_____

_____

_____

_____

Are standards National Institute of Standards and Technology (NIST) traceable? ☐ Y ☐ N

Did calibration meet equipment manufacturer's specifications? ☐ Y ☐ N

Calibration was performed by:_____

Remarks:

_____

_____

_____

_____

_____

_____

_____

_____

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Note: Representative calibration statement Refer to Forms Master list for current version.

Figure 11. Typical Calibration Statement.

8.0 Records

Records for Building 4623 shall consist of (a) memoranda that contain test results and that are stored electronically in the Materials and Processes Technical Information System (MAPTIS) and (b) calibration records.

8.1 Memoranda

Memoranda containing test results shall be retained indefinitely by EM10. These memoranda shall be stored electronically in the MAPTIS database and shall be accessible by test request number or memorandum number.

8.2 Calibration Records

8.2.1. **All equipment requiring calibration shall be in current calibration, in accordance with EM10-OWI-CHM-050,** *Building 4623 Guidelines for General Operations.*

8.2.2. Form EM10-F-CHM-018 (Figure 1, section 7.0), shall be used to document the calibration of all Category IV and Category V equipment.

8.3 Maintenance of Records

8.3.1. Memoranda less than 10 years old shall be maintained in ready-access files in MAPTIS; memoranda 10 years old or older shall be automatically transferred to historical files.

8.3.2. Calibration records shall be maintained on site for a minimum of 10 years, filed and indexed by test request number. These shall be stored in a manner that will protect them, *e.g.*, in a test folder stored in a metal file cabinet. After 10 years, calibration records shall be transferred to historical files.

8.3.3. The original test records shall be saved for a minimum of 5 years.

9.0 Tools, Equipment, and Materials

9.1 Tester Standard Configuration

Tests are conducted in either the Small Flammability Chamber or the Large Flammability Chamber, depending on the size of the sample and other factors. The test procedures are identical for each chamber. Procedures **shall be followed** closely to achieve accurate and reliable results and to ensure the safety of all personnel and of the facilities involved.

The test system comprises two chambers in Building 4623, Room 126:

- Small Flammability Chamber, a 3-ft diameter, 33.4 ft^3, horizontal steel tank with door and three view ports
- Large Flammability Chamber, a 4-ft diameter, 103.2 ft^3, horizontal steel tank with door and three view ports.

The chambers are equipped with vacuum pumps, oxygen and nitrogen supply lines and pressurization system, electrical sources and feedthroughs, ignition heating devices, thermocouples, pressure gauges, video cameras and recorder, interior chamber lighting, and a control console. Personnel shall **refer** to the *Small* or *Large Flammability Chamber Configuration Control Books* located in the bookcase on the north wall of Room 126 for electrical and mechanical schematics of these systems. Figure 12 shows the sample position for an upward propagation burn. Figure 13 depicts a needle rake mount for a thin film sample. Figure 14 shows a standard sample mounted on the tester. Figure 15 is the small heating chamber.

9.2 Procedure for Deviations

Deviations to the baselined tester configuration require NASA written approval. It is the responsibility of the test engineer to obtain the appropriate approval from the NASA COTR. After written approval is received, the change shall be added to the appropriate configuration control book.

9.3 1400B Series Oxygen Analyzer

(Reference: *1420B Oxygen Analyzer Instruction Manual/01420/001B1.* Servomex Handout 7981-3488 9/93.

A magneto-dynamic paramagnetic oxygen analyzer provides excellent accuracy between 0.1 and 100% O_2 concentrations, fast response, and the capability of measuring oxygen in the presence of hydrocarbons. Unlike fuel cell oxygen sensors, the Servomex sensor is unaffected by acid gases, cannot be poisoned,

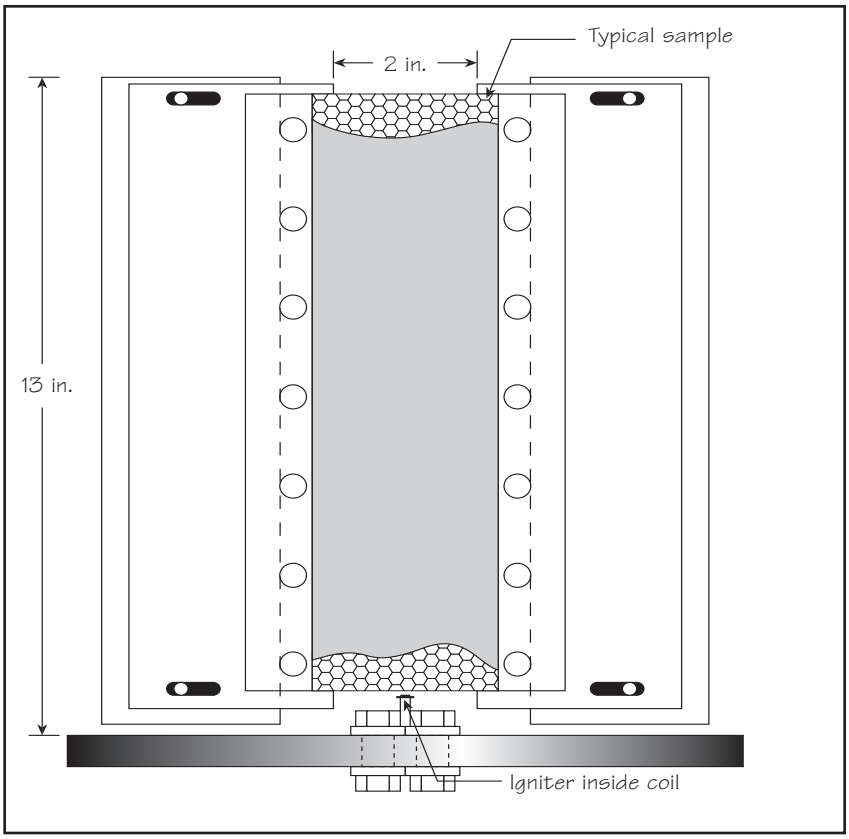

Figure 12.
Typical standard test setup for Test 1, Upward Flame Propagation.

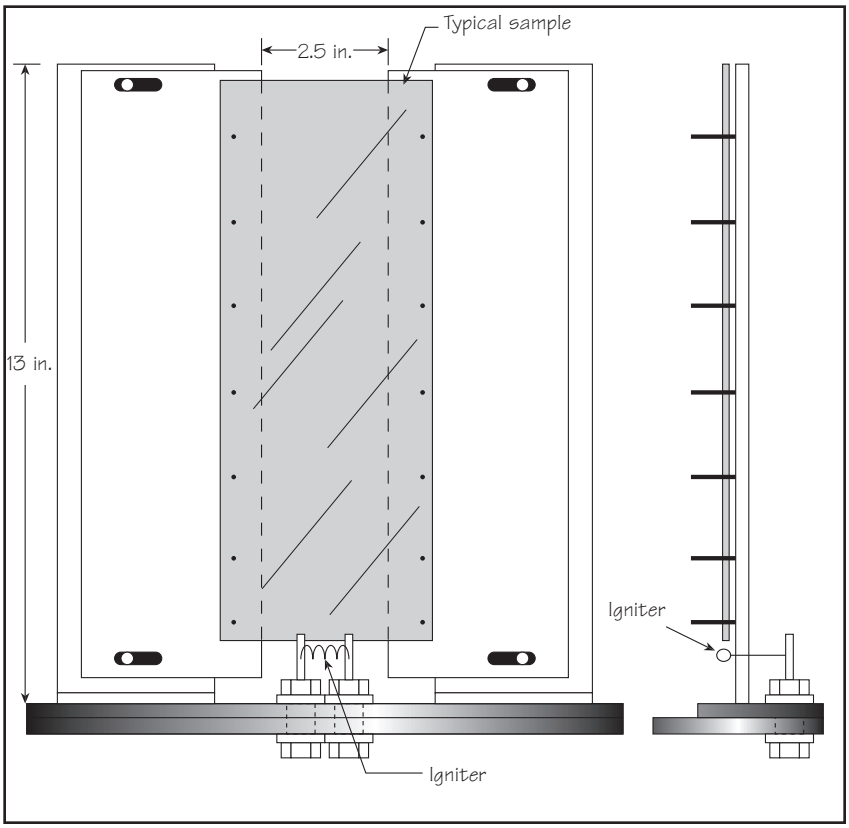

Figure 13
Typical needle rake mount for thin film sample.

Note: Illustrations are representative. Actual appearance may vary.

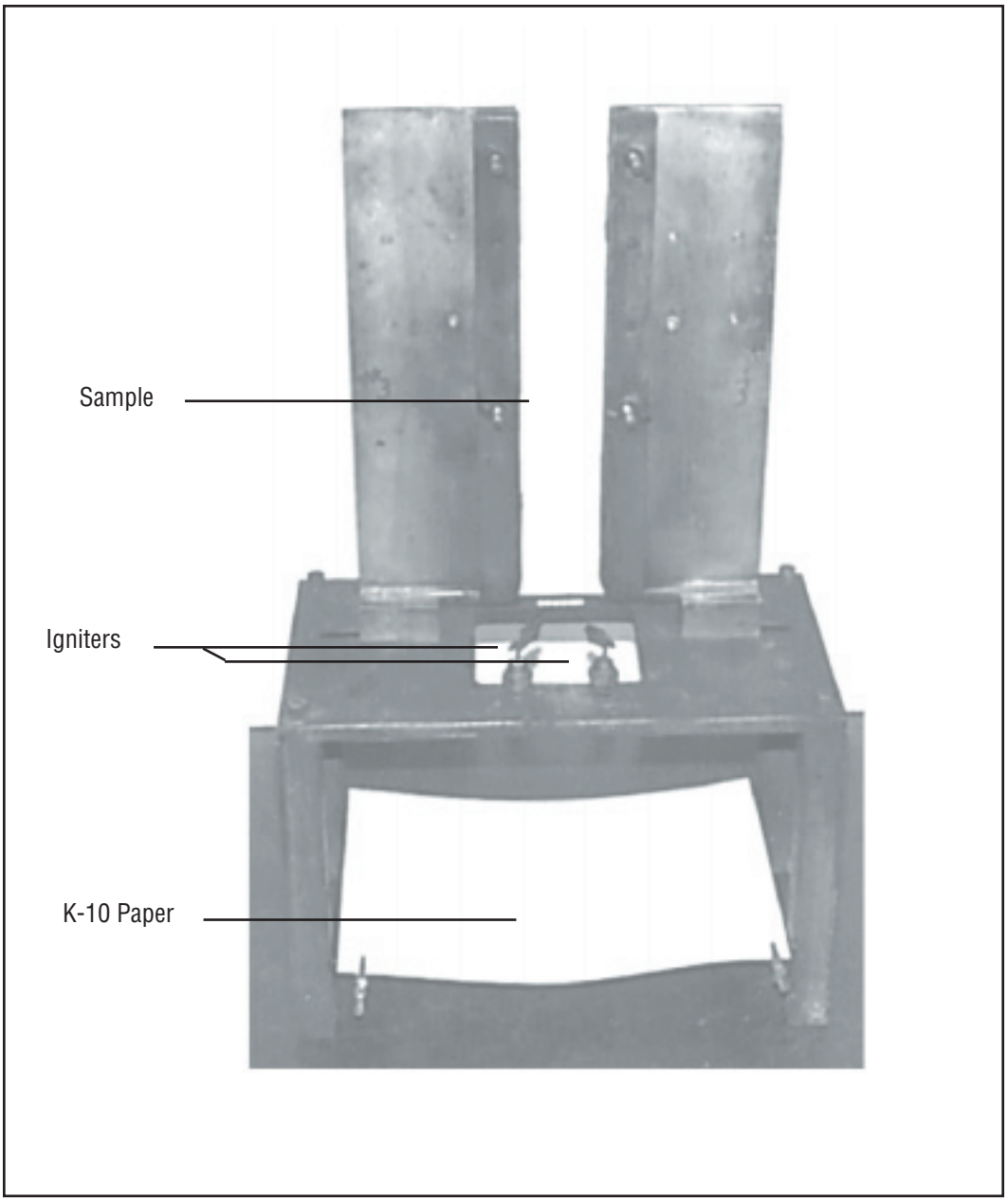

Figure 14.
Test 1 Standard Sample and Test Stand.

and virtually has an unlimited life span. Since oxygen is one of only a few gases that exhibit paramagnetism (attraction by a magnetic field), this sensor is highly specific to oxygen when measured in a wide variety of background gases.

In the Servomex 1400B series measuring cell, the O_2 concentration is detected by means of a dumbbell mounted on a torque suspension in a strong, non-linear magnetic field. The higher the concentration of O_2, the greater the dumbbell is deflected from its rest position. Deflection is observed by an optical system and twin photocells connected to an amplifier. Around the dumbbell is a coil of wire. A current passes through this coil to return the dumbbell to its original position. The current is measured and is proportional to the O_2 concentration.

Figure 15.
Small Heating Chamber.

9.3.1. The sampling system of the Servomex 1400B Series Oxygen Analyzer includes a combination filter/automatic flow control device, designed to keep a constant flow of sample gas through the measuring cell for varying input pressures and to prevent the entrance of particulate matter into the measuring cell. Excess flow is vented to the bypass.

9.3.2. Specifications

- Repeatability: better than ±0.1% oxygen under constant conditions
- Response time: less than 15 seconds up to 90% oxygen; approximately 50 seconds above 90% oxygen
- Filtering: a 0.6 micron replaceable filter integral to the automatic flow control device .
- Materials exposed to sample gas: stainless steel, pyrex glass, brass, platinum, epoxy resin, viton, nylon, neoprene, polypropylene, and glass fiber filler
- Operating temperature: 32 to 113 ˚F
- Relative humidity: 0-85%, non-condensing
- Input pressure: 14.7 to 24.7 psia

9.3.3. Operation

The *test operator* **shall perform** the following procedures:

9.3.3.1. Setting the zero: To set the zero, a zero gas shall be used that is certified 99.9+% pure (preferably gaseous nitrogen), and the certification shall be traceable to NIST. **Introduce** the zero gas at a pressure less than 10 psig (24.5 psia) to the gas inlet on the rear of the analyzer. **Adjust** the zero control, located behind the flip-down panel below the display, to give a reading of 0.0 on the display. *If the range of adjustment is inadequate,* **notify** the test engineer.

9.3.3.2. Setting the span: **Introduce** clean, dry gas at a pressure of less than 10 psig (24.5 psia) to the analyzer's gas inlet. (This gas shall be certified and the certification traceable to NIST.) **Adjust** the span control (on front behind the flip down door just below the digital display) to give a reading of the value of the introduced gas. *If, after setting the span, the oxygen analyzer does not read the ambient oxygen concentration when ambient air is reintroduced to the system,* **replace** the oxygen analyzer with one in calibration, and **notify** the test engineer. The ambient oxygen concentration reading varies based on the atmospheric pressure.

9.3.4. Taking a reading: Once the analyzer is readied for use by connecting the gas sample line to the gas inlet on the rear panel and the O_2 Analyzer switch on the main control panel of the test console is activated, the oxygen concentration of the test gas displays on the front panel of the analyzer as well as on the digital display (if used) on the Main Control Panel and on the appropriate channel of the Westronics strip chart recorder (if used).

9.4 Required Tester Maintenance

The standard maintenance program for these test chambers and related control equipment is divided into weekly, bi-weekly, monthly, and annual service. In addition, the program involves a maintenance log, calibration, and a required parts inventory. Personnel **shall refer** to the drawings in the *Small* or *Large Flammability Configuration Control Book*, as needed. The *test operator* **shall perform** the following procedures:

9.4.1. Weekly Maintenance.

9.4.1.1. **Verify** the span on the oxygen analyzer with a known concentration of pre-mixed compressed gas (section 9.3.3.2). The mixed gas bottles are marked with a certified concentration. **Adjust** the span on the oxygen analyzer to read the exact percent certified on the mixed gas bottle.

9.4.1.2. **Verify** the cleanliness of the interior of the test chamber and vacuum it thoroughly, if needed.

9.4.1.3. **Verify** the cleanliness of all sample holders and test stand equipment; wash if necessary.

9.4.1.4. **Check** for electrical shorts on test stand electrodes.

9.4.1.5. **Verify** the cleanliness of the test chamber lighting fixtures; **clean** if needed.

9.4.1.6. **Inspect** all electrical wiring for insulation damage, loose or shorted connections, etc.

9.4.1.7. **Verify** that all thermocouples are reading adequately; also check all thermocouple wiring connections. **Use** an ice water bath to determine freezing point values. (Temperature readings shall be 32 ±2 ˚F.) **Check** values in ambient air as well. These values shall be within 3 ˚F of each other. *If they are not,* **change** thermocouples. *If values are still not within 3 ˚F of each other,* **replace** the thermocouple read-out device with one in current calibration. No adjustment of the read-out device is allowed.

9.4.1.8. Step deleted.

9.4.1.9. **Record** any problems discovered during weekly maintenance in the tester maintenance log, and **obtain** engineering approval of the maintenance log entry.

9.4.2. Bi-Weekly Maintenance

9.4..2.1. **Check** the particulate filter on the test chamber for any blockage, interior trash buildup, or breakthrough (visible dirt/trash on the exterior). *If any of these conditions exist,* **vacuum** the element thoroughly, and **reinstall** it.

9.4.2.2. **Inspect** the dryer filters on the oxygen analyzer system. I*f the filter appears wet or dirty,* **replace** the filter. **Refer** to the *1420B Oxygen Analyzer Instruction Manual* for instructions on replacement of the filter.

9.4.2.3. **Lubricate** all threads on the door clamping device of the *large chamber*. **Use** Tri-Flo® spray lubricant or equivalent. *If debris appears to be caking on the threads*, **wipe** the debris off the threads with a dry rag. Then **lubricate** all threads again. **Discard** hazardous waste rags in the hazardous waste *Organic Rags and Debris* drum located in the chemical storage room, Room 128, in the fenced area south of Building 4623.

9.4.2.4. **Check** the hydraulic fluid reservoir, and **lubricate** the door clamping mechanism of the *small chamber* with Tri-Flo® spray lubricant or equivalent. **Place** a thin film of Tri-Flo® spray lubricant or equivalent on the door and rotating clamp ring flanges.

9.4.2.5. **Remove** the ECV to the oxygen analyzer, and **clean** the valve orifice, or *if it is extremely dirty*, **replace** the valve, and **submit** the dirty one for valve servicing.

9.4.2.6. **Record** any problems discovered during bi-weekly maintenance in the tester maintenance log, and **obtain** engineering approval of the maintenance log entry.

9.4.3. Monthly Maintenance

9.4.3.1. **Inspect** all vacuum pumps. **Pay particular attention** to the belts and pump oil. *If the belts appear worn*, **replace** them; *if the pump oil is black*, **drain** it, and **replace** it with DuoSeal® Oil, (Cat. No. 1407K). Waste vacuum pump oil is a controlled waste item and shall be placed in the *Waste Vacuum Pump Oil* drum in the hazardous waste storage area in the chemical storage room, Room 128, located in the fenced area south of Building 4623.

9.4.3.2. **Inspect** the large test chamber vent valve, ASCO Model EF8210B56N. *If the vent valve appears dirty*, **replace** the valve, and **send** the dirty one to the valve shop for servicing.

9.4.3.3. **Clean** the test chamber vent valve, Whitey Model 556TF16. (**Refer** to the manufacturer's literature for more information.) **Verify** that the **POWER** button on the console is not lit. **Remove 3** of the **4** bolts on the valve body, and **disconnect** the pneumatic actuation line. **Rotate** the valve body out to allow access to both ports of the valve body. **Wipe** clean the ball and all reachable interior cavities. **Ensure** that there are no cuts or scratches that might prevent the ball from properly sealing. *If defects are found*, **replace** the valve with a spare, and **send** the damaged valve to the valve shop for servicing. When reinstalling the valve body, **make sure** that the bolts are not tightened beyond the manufacturer's suggested torque limits for those bolts. Once the valve body is back in place, **reconnect** the pneumatic actuation line, and **run** a pressure and leak test to verify operations.

9.4.3.4. **Examine** all port windows and sacrificial glass for scratches, cracks, or chips. **Report** any imperfections to the test engineer. **Replace** the glass if the observed imperfections are severe or are adversely impacting the glass performance.

9.4.3.5. **Adjust** the zero on the oxygen analyzer. **(Refer** to section 9.3.3.1 for instructions on the procedure.) After the zero is adjusted, **verify** the span with

a certified cylinder of technical grade (99+%) oxygen. The gas certification **shall** be traceable to NIST. **Adjust** the span to read the exact percentage certified on the oxygen cylinder.

9.4.3.6. **Record** any problems discovered during monthly maintenance in the tester maintenance log.

9.4.4. Annual Maintenance: **Remove** the small chamber vacuum gate valve, and **replace** it with a gate valve serviced by the Valve Lab. **Prepare** the removed gate valve to be sent to the Valve Lab. *If the gate valve begins to leak before the scheduled annual service,* **replace** the faulty valve, and **send** it to the Valve Lab for repair.

9.4.5. Maintenance Log. **Document** any maintenance to the test chamber or setup in the *Small Flammability Chamber* or *Large Flammability Chamber Maintenance Logs* to provide a history of each tester. **Obtain engineering approval for all maintenance and repair actions before proceeding.**

9.5 Calibration

Tables 1 and 2 list all calibrated equipment used in the flammability test area. Calibration dates are given as an illustration rather than as a schedule. Calibrated equipment lists of all categories for this OWI are kept by the primary calibration contact for Building 4623. Self-calibration of some equipment will be performed. This self-calibration will be recorded on form EM10-F-CHM-018 (Figure 11, section 7.2).

9.6 Required Parts Inventory

The parts necessary to properly perform Tests 1, 8, and 10 are listed in Table 3. Where appropriate, the quantity includes the minimum number of spares.

Item	Model #	Serial #	Cal. #	Due Cal.	Cal. Date
Digital Thermometer	BB202	none	M631247	13-May-97	13-May-96
Digital Thermometer	BB202	none	M626650	14-Jan-98	14-Jan-97
Digital Thermometer	BB202	none	M631251	13-May-97	13-May-96
Digital Thermometer	BB202	none	M631252	13-May-97	13-May-96
Microthermocouple	TC-K(60MP)	n/a	none	n/a	n/a
Microthermocouple	TC-K(60MP)	n/a	none	n/a	n/a
Microthermocouple	TC-K(60MP)	n/a	none	n/a	n/a
Microthermocouple	TC-K(60MP)	n/a	none	n/a	n/a
Thermocouple	TC-K 1204GP	none	none	n/a	n/a
Oxygen Analyzer	1400	661	1221427	18-Apr-97	18-Mar-97
Oxygen Analyzer	1400	682	1218644	03-May-97	03-Apr-97
Pressure Transducer	TJE/5453-10	317103	M622559	21-Aug-97	21-Aug-96
Pressure Gauge	060-3147-01	256262	M622125	21-Aug-97	21-Aug-96
DC Amp Gauge	0-100 Amp	none	M623055	27-Jul-97	27-Jun-96
DC Amp Gauge	0-100 Amp	none	M623054	27-Jul-97	27-Jun-96
Shunt Bar	100A/50mv	none	M623069	28-Jun-97	27-Jun-96
DC Power Supply	LT-862	92T049997	1443848	14-May-97	14-Nov-96
DC Power Supply	LT-862	92T043639	1443847	13-Jun-97	13-Dec-96
DC Power Supply	LT-862	94T043641	1443845	17-Jul-97	17-Jan-97
Thickness Gauge	179-756	456184	1445315	DAILY	DAILY
Pressure Transducer	TJE/5453-10	298286	M621995	04-Mar-98	04-Mar-97
Pressure Gauge	060-3147-01	256604	M622454	04-Mar-98	04-Mar-97
Digital Scales	PM 100	K410193	009089	17- Jan-98	17-Jan-97
Digital Scales	XT 12000	16913	G81127	30-May-97	30-May-96
Micrometer	293-721-10	0169640	M631095	11-Mar-98	11-Mar-97
Strip Chart Recorder	2600	1064	1740913	13-Jan-98	13-Jan-97

Table 1.
Calibration List for the Small (33 ft^3) Flammability Chamber

Item	Model #	Serial #	Cal. #	Due Cal.
Digital Thermometer	BB202	none	M627398	11-Mar-98
Digital Thermometer	BB202	none	M627400	04-Mar-98
Digital Thermometer	BB202	none	M627401	04-Mar-98
Digital Thermometer	BB202	none	M627404	04-Mar-98
Thermocouple	TC-K 1204GP	none	none	n/a
Thermocouple	TC-K 1204GP	none	none	n/a
Thermocouple	TC-K 1204GP	none	none	n/a
Thermocouple	TC-K 1204GP	none	none	n/a
Oxygen Analyzer	1400	660	1221428	22-May-97
Oxygen Analyzer	1400	672	1218642	03-May-97
DC Amp Gauge	1212	none	M625449	10-Apr-98
Pressure Gauge	GM	256254	M622123	21-Aug-97
Pressure Transducer	5453-10	317116	M622556	21-Aug-97
DC Power Supply	LT-862	43643	1443846	07-Oct-97
DC Power Supply	LT-862	49999	1443849	07-Oct-97
Thickness Gauge	179-756	456184	1445315	DAILY
Digital Scales	PM100	K41093	009089	17-Jan-98
Digital Scales	XT 12000	16913	G81127	30-May-97
Strip Chart Recorder	2600	1064	1740913	13-Jan-98

Table 2.
Calibration List for the Large (103 ft^3) Flammability Chamber

Table 3.
Required Parts Inventory for Tests 1, 8, and 10.

PART	QUANTITY
Igniters	
Chemical	120 each
Silicon	24 each
Wire, nichrome 20 AWG	100 ft
Wire, nichrome 18 AWG	100 ft
Alligator clips	50 each
K-10 paper (9310-01-074-9408)	50 each
Test Stand (standard)	3 each
Test Stand (needle rake)	3 each
Pressure Transducers	
Sensotec 5443-10	4 each
Sensotec A5/743-03	4 each
Pressure Gauge	
Sensotec 3147-10	6 each
Marotta Valves MV74	4 each
GNC Gate Valve	1 each
Whitey Gate Valve	1 each
Vacuum Pumps	
Kinney KDH 60	2 each
Kinney KDH 85	1 each
Vacuum Pump Oil, DuoSeal	24 qt bottles
Grease, Krytox® 240AC	2 tubes
Oxygen Analyzer	
Servomex 1420B	2 each
Power Supply	
Lambda LT-862	2 each
Shunt Bar	
Simpson 100 amp	2 each
Simpson 200 amp	2 each
DC Amp Gauge	
0-50 amp	2 each
0-100 amp	2 each
0-200 amp	2 each
DC Volt Gauge	
0-30 VDC	2 each
AC Variable Transformer, 0-125 VAC	2 each
Thermocouples	
Digital Thermometers, Omega 202K	4 each
Thermocouples, Medtherm TCK INC 100467	8 each
Microthermocouples, Medtherm TCK 1204GP	8 each
Wire, Omega XC-K-20	100 ft
Connectors, Omega NHXH-K-F	10 each
Connectors, Omega NHXH-K-M	10 each
Feedthrough, Omega PTS-5-K	4 each
Power Feedthrough, ISI 9425000	4 each
Switch, Pushbutton, EAO, 84F-1505	2 each
Video	
Lamps T-1 24 V	12 each
Camera, Panasonic WV-CL110	2 each
Drive Unit, Panasonic, WVPS11A	2 each
VHS T-120 Tapes	10 each
VHS Head Cleaners	2 each
Internal Light Fixture Stikup	6 each
Internal Lamps, Sylvania, FEV 54441-3	10 each
Monitor, Panasonic, BT-S1370Y	1 each
Chamber Door o-ring, 37 3/8 ID, Viton	2 each
Port Windows, GE NSG-0Z, 9 7/8 OD	4 each

10.0 Personnel Training

The nature of testing that occurs in Building 4623 is complex and involves potential hazards; therefore, all test operators **shall complete** the requirements for Category 1 Credentials before conducting any test, and all tester maintenance personnel **shall complete** the requirements for Category 2 Credentials.

- **Category 1 Credentials** qualify personnel to perform basic test operations.
- **Category 2 Credentials** qualify personnel to maintain and modify testing apparatus.

Category 1 Credentials - Basic Operations

To obtain Category 1 Credentials, the test operator **shall complete** training in following areas:

- Handling of Compressed Gas Cylinders
- Oxygen Compatibility
- Use of Personal Protective Equipment
- General Safe Laboratory Practices
- Hazardous Waste Disposal.

Category 1 Credentialling also requires:

- Successful completion of an annual physical examination conducted by the medical facility at Marshall Space Flight Center (or equivalent), including a hearing exam
- A demonstration of knowledge of the test and equipment by the completion of two successful test sets under the supervision of the test engineer.
- A demonstration of knowledge of the OWI. Candidate test operators **shall thoroughly read** the test OWI and **sign** a statment confirming that they have read and understand the OWI. Each **shall be issued** a personal copy of the OWI.
- Passing of a written test covering the OWI. The test s**hall be administered** by the test engineer.

A copy of the written test, along with the signed statement and the training record, **shall constitute** verification of credentials. Training records **shall be kept** on file as proof of training. These records **shall include** training expiration dates and required refresher courses.

Category 1 Credentials **shall expire** after a period of 2 years. After that time, recredentialling **shall be required.**

Category 2 - Tester Maintenance and Modifications

Personnel seeking **Category 2 Credentials shall become** qualified and credentialled through training classes approved by the candidate's supervisor or through training classes completed during previous employment. Training in the following areas **shall be required**:

- Compressed Gases and Working with Compressed Gas Lines and Fittings
- Vacuum Pump Operations
- Basic Electrical Wiring.

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EMERGENCY PHONE NUMBERS

Emergency..... 911

Medical Center..... 4-2390

Industrial Safety..... 4-0046

Chemical Spills..... 4-4357

Safety Monitor
Building 4623..... 5-0358